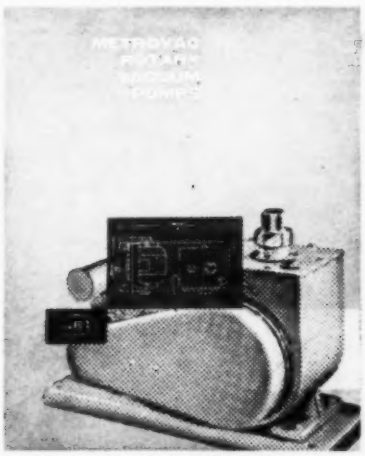
NATURE

A Weekly Journal of Science

Vol. 189, No. 4764 SATURDAY, FEBRUARY 18, 1961 2s. 6d.

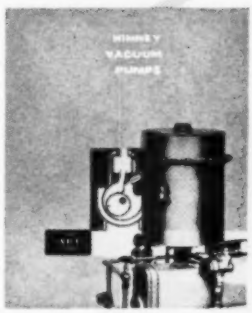


AEI

METROVAC

VACUUM PUMPS AND EQUIPMENT

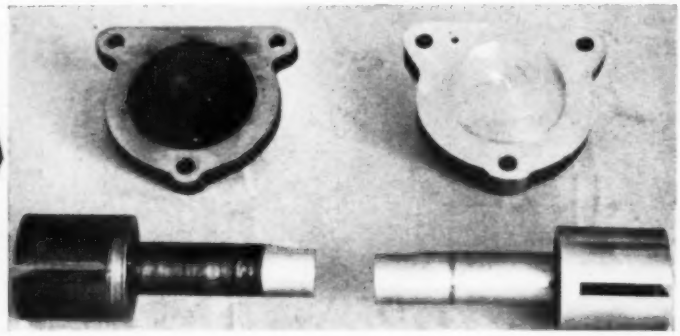
Booklets detailing the new A.E.I. range of 'Metrovac' rotary vacuum pumps, vacuum gauges, high vacuum unions and Kinney pumps are now available.



Contact your local AEI District Office or write direct to

AEI

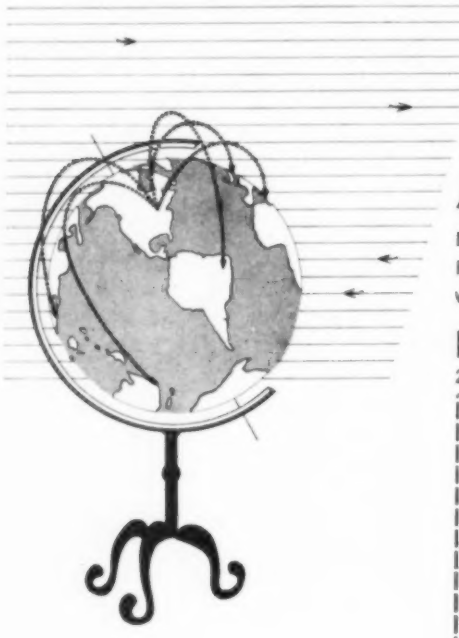
Associated Electrical Industries Limited
Instrumentation Division
SCIENTIFIC APPARATUS & X-RAY DEPARTMENT
Trafford Park, Manchester, 17



This unretouched photograph shows the rotors and end plates of two pumps after running for similar periods pumping hydrochloric acid and water vapour. The one on the left was run on a straight mineral oil and the other on a "Speedivac" additive-type oil.

"Speedivac" vacuum pump oils are the result of prolonged research to obtain the finest lubricating and protecting medium to ensure optimum performance under all conditions.
These are mineral or mineral-based oils prepared from selected crudes and refined by advanced methods for use in high vacuum rotary pumps. Each batch is stringently "acceptance-tested" before being placed in store in the sealed customer packings.
Grades 17 and 18, used in "Speedivac" gas-ballast pumps, contain multi-functional additives which afford an important degree of protection against corrosion.

EDWARDS HIGH VACUUM LTD | MANOR ROYAL | CRAWLEY | SUSSEX | Crawley 1500



INSTANT SERVICE
ANYWHERE IN THE WORLD

From the world's most complete inventory of quality biochemicals, N.B.Co. offers the speediest delivery anywhere in the world at economical prices.

NUTRITIONAL BIOCHEMICALS CORPORATION
21010 MILES AVENUE CLEVELAND 28, OHIO

Send for our free October, 1960 Catalog containing more than 2600 items. Fill out coupon and mail today for your copy.

Name .....
Organization .....
City .....
State ..... Zone ..... (N)

Are you measuring VIBRATION, EXPANSION, or DIMENSIONS OF PLIABLE OR INACCESSIBLE OBJECTS?
The most simple and economical solution to your problem is possibly illustrated on this page.

FOR MEASURING MICROSCOPES

UNIVERSAL MEASURING MICROSCOPE and CATHETOMETER

Range 50 cm. Can be used in three different planes as a cathetometer (focus: 15" to infinity) or a microscope (focus: 1½"). 360° rotation on the heavy levelling base. Vernier scales read to 0.05 mm. over entire range of 50 cm. and 00.1 mm. over any selected range of 25 mm.

CAT. NO. 6147

TWO-DIMENSIONAL MEASURING MICROSCOPE

An extremely accurate method of measuring in two horizontal directions at once. Range 20 cm. x 10 cm. Direct reading to better than 0.01 mm. Supplied with cabinet.

CAT. NO. 6164

UNIVERSAL MEASURING MICROSCOPE AND CATHETOMETER

Range 30 cm. Very similar to cat. no. 6166 but fitted with fixed base without spirit levels. Supplied with cabinet.

CAT. NO. 6166

The NEW Pye range of measuring microscopes and cathetometers is designed to cater for numerous measuring applications in research and industry. Each instrument can perform several different functions with high accuracy, and new design features make operation fast and simple.
Either Metric or English calibrations can be specified.
Quality of craftsmanship and materials are of the highest standard yet careful design has resulted in a very competitive price level. Please ask us to send you descriptive leaflets.

"ACCURACY OF CALIBRATION AND ENGRAVING OF THESE INSTRUMENTS TO B.S. 887"

CAT. NO. 6192

PRECISION CATHETOMETER

Range 100 cm. For vertical use as a cathetometer or measuring microscope. 360° rotation of telescope. The heavy levelling base is fitted with sensitive levels.

CAT. NO. 6150

TELESCOPE/MICROSCOPE KIT

Contains components which make up a telescope (focus: 15" to infinity) and microscope (focus: 1½") fitted with spirit level and slow-motion focusing. For use with cat. nos. 6164, 6166 and 6192.

SCIENTIFIC PYE INSTRUMENTS

W. G. PYE & CO. LTD.

GRANTA WORKS, P.O. BOX 60, CAMBRIDGE, ENGLAND
Telephone: CAMBRIDGE 58866 (5 lines) Telegrams: PYE CAMBRIDGE

ISOTOPIC TRENDS

STANDARDISED RADIOACTIVE SOLUTIONS
for calibration

For uses such as calibrating equipment for measuring radioisotopes, The Radiochemical Centre offers two ranges:

1. Solutions of high radioisotopic purity whose activity has been established by an absolute method, such as 4π beta counting; effective standard deviations are less than 3%.

The following absolutely standardised solutions are available at fixed times of year.

CAESIUM-137	GOLD-198	SODIUM-22
CALCIUM-45	IODINE-131	STRONTIUM-89
CERIUM-141	MERCURY-203	STRONTIUM-90
CERIUM-144	PHOSPHORUS-32	SULPHUR-35
COBALT-60	RUTHENIUM-106	THULIUM-170

2. Solutions standardised by comparison with an absolutely standardised solution; effective standard deviation less than 5%.

The following solutions are available either once a month or from stock:

CAESIUM-137	GOLD-198	POTASSIUM-42
CARBON-14	IODINE-131	SODIUM-24
COBALT-60	LEAD-210	STRONTIUM-90
	PHOSPHORUS-32	

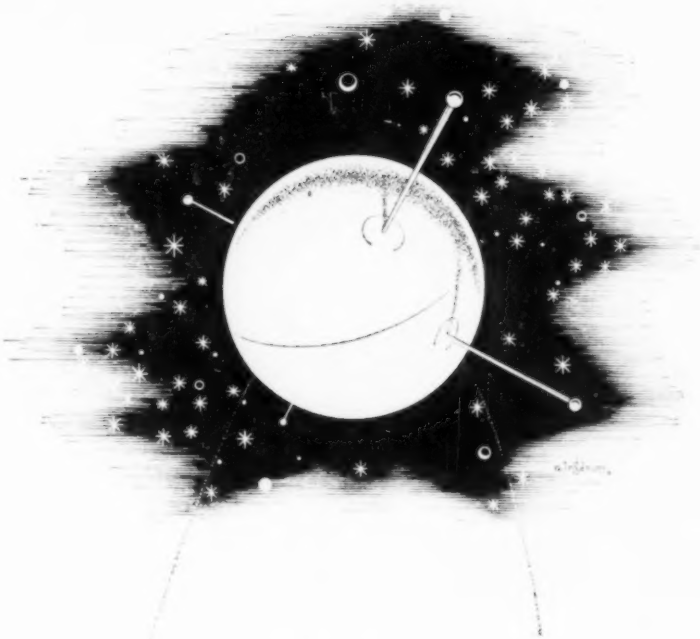
Please write for complete details and charges.

Comprehensive catalogues including more than 500 labelled compounds are available on application.

THE RADIOCHEMICAL CENTRE

AMERSHAM · BUCKINGHAMSHIRE · ENGLAND

TAS/RC 65



High Opportunity for engineering and science graduates

Today, the scientific and engineering side of the Post Office offers ambitious young graduates the most attractive opportunities in the long history of the service. The current rapid advance of scientific discovery and developments in the field of communications opens the way to careers of an interest and importance unknown even ten years ago. There are thirty new vacancies for graduate engineers and scientists for work on new projects:

SOLID STATE PHYSICS – SEMICONDUCTORS AND MAGNETICS
MICROWAVE TRANSMISSIONS – BEAM AND WAVEGUIDE
SPACE RESEARCH – COMMUNICATION BY SATELLITE
TRANSOCEANIC TELEPHONY – REPEATERS AND CABLE ROUND THE WORLD
ELECTRONIC CIRCUITRY AND SWITCHING
MATHEMATICS AND COMPUTER TECHNOLOGY

The future is limitless. Graduates (and those in their finals year) are invited to write now for full information to:
T. J. Rees, Engineering Dept. O (NA2), 2-12 Gresham Street, London, E.C.2.

GPO ISSUED BY THE G.P.O

RESEARCH COMMUNICATIONS ELECTRONICS DATA TRANSMISSION

CTH/GPO1/4

Are you the polydigital* type?

By this*, of course, we mean the kind of person who can turn his hand to anything. But polydigital or not, a career in Courtaulds may well be the career for you.

In Courtaulds today there are real opportunities for versatile people just as much as there are for those who are specialists by nature—for talented people of general as well as of technical education.

The reasons for this are simple. Courtaulds is no longer a single company concentrating on man-made fibres. It is an organization of many companies, active in widely varying fields.

Some are concerned with fibres, others with their finished products such as fabrics and garments, others again cover a wide range of products—paints, plastics, chemicals, wood pulp, 'Cellophane,' metal containers and packaging materials. All these seemingly diverse activities are dovetailed into a structure which is a growing force in world economics.

Naturally, a group of this size needs many different kinds of people to run it. Scientists and engineers to carry out research, to develop and to produce—and marketing men and administrators to organize, to plan and to sell.

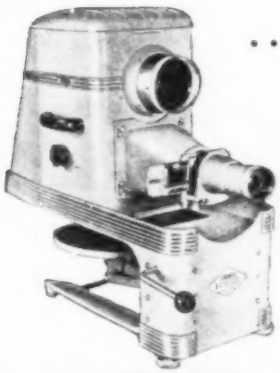
If you have a good degree, or expect to get one, you may find a full and interesting life in the modern Courtaulds. And you will also find the diversity of the organization a powerful added attraction.

Courtaulds

16 St. Martin's-le-Grand, London, E.C.1

MAN-MADE FIBRES · CHEMICALS · ENGINEERING · PACKAGING · PAINT · PLASTICS · TYRE CORD · FABRICS · WOOD PULP

Maid of all work!



. . . if you want to project

PHOTOGRAPHS
DRAWINGS
MAPS & CHARTS
MANUSCRIPTS
BOOK PAGES
MODELS
FILM STRIPS
& SLIDES

ALDIS *. . . here's your answer*

EPIVISOR Regd.

This versatile instrument projects greatly enlarged, perfectly defined images of flat and solid objects, as well as film strips and slides. Full details on request, with name of nearest dealer who will be pleased to demonstrate.

NEVILLE BROWN & CO. LTD. 77 Newman Street, London, W.1

ENDECOTTS
TEST SIEVES
For Accuracy!

POCKET INTERCHANGER SIEVES

'ENDROCK' TEST SIEVE SHAKER

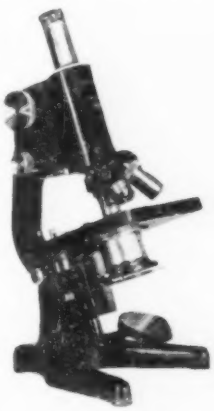
TEST SIEVES
B.S. 410: 43 U.S. Standards and Tyler Equivalents

We operate a Recovering Service

Consistent mechanical action—saves valuable time of skilled personnel

ENDECOTTS (FILTERS) LTD. Phone: LIBerty 8121/2/3
Dept. B Lombard Rd., London, S.W.19. Grams: Endfilt, London

A fine instrument, the WATSON 'Service'. . .



The 'Service' is to-day's finest student laboratory microscope. It has simplicity, allied with the highest quality—in fact a fine example of the Watson Standard. It is built for a lifetime of constant use. There is a comprehensive range of accessories designed to make the 'Service' suitable for more complex work. See the Watson 'Service' before you make your decision. Write to us for full descriptive literature, or arrange an appointment with one of our representatives.

Since 1837 Watsons have been making fine optical instruments to the highest possible standard—the 'Watson Standard.'

WATSON

W. Watson & Son Ltd.
Barnet, Herts.

STANTON sets the STANDARD

1 SECOND IN 6 YEARS corresponds to a Standard Deviation of 1 microgramme on a 200g balance. Such is the remarkable accuracy attained on a Stanton High Precision balance. That's why the laboratories in 5 continents, charged with maintaining the world standards of mass, turn to Stanton for their precision balances and weights.

That is why the **STANTON**

"ULTRAMATIC" BALANCE

has achieved its success

Completely new, this latest Stanton achievement has all the good looks and performance of a precision instrument. Streamline-built for speed and accuracy.

GREATER EASE OF USE

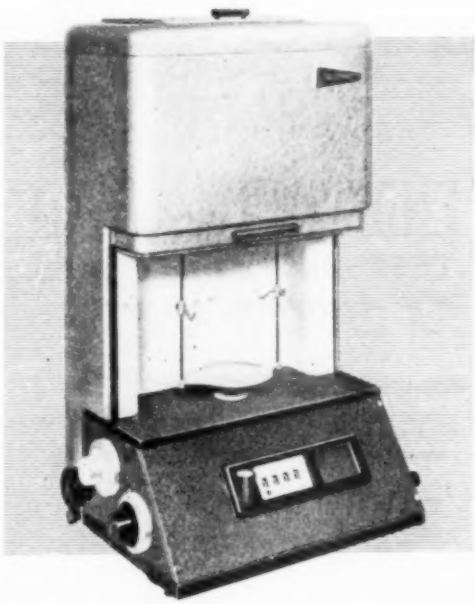
A large accessible pan space—dual release at bench level—counter indicator for weights adjacent to graticule screen at base of balance.

GREATER WEIGHING SPEEDS

Both hands can be used—partial release switch eliminates slow starting—convenient banking of colour-marked weight loading dials.

INCOMPARABLE RELIABILITY

Applied load of proven dependability—fitted with Stanton Synthetic Sapphire (Corundum) Planes, agate arrestment bearings and knife guards—stainless steel weights—Class 'A' adjustment. Dial weight loading up to 200 grammes.

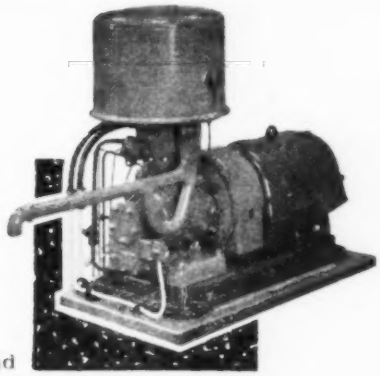


STANTON ULTRAMATIC **Balances**

Regd Trade Mark

STANTON INSTRUMENTS LTD . 119 OXFORD STREET . LONDON W 1

Telephone: Gerrard 7533 · Cables: Stanbal London

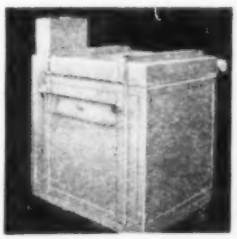


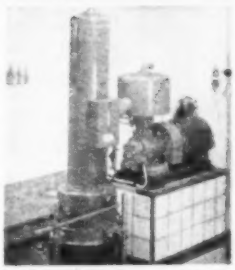
a versatile, economic and

ready supply of cold

down to minus 200°C

UNIVERSAL COOLING PLANT PLA 107 - The Philips PLA 107 is a gas liquefier with an average output of 7.5 litres per hour, when used as air-liquefier, available immediately after starting-up. It attains temperatures from room temperature down to minus 200° C at atmospheric pressure in a single stage. Cooling system and production cycle are completely separated; the high purity of the product is in no case influenced by moving machine parts. The Philips PLA 107 is self-contained with all-in-one construction, small dimensions and low weight. It is delivered ready for installation, and incorporates full safeguards against any failure.





The plant is delivered with a standard cold exchanger head, other heads are available on request in order to operate the machine (at atmospheric pressure) for:

LIQUEFACTION OF REFLUX, when used with Fractionating Column for the production of liquid nitrogen at a rate of 6.5 litres/h.

COLD SOURCE for the **Cold Box ECB 380** for general cold treatment and environmental testing down to minus 180° C at a capacity of 380 litres/h.

OTHER UNIVERSAL COOLING MACHINES with capacities up to 36,000 kcal/h at minus 195° C or 70,000 kcal/h at minus 100° C are also available.

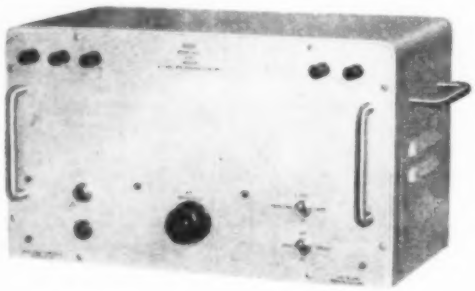
PHILIPS
CRYOGENERATORS

N.V. PHILIPS' GLOEILAMPENFABRIEKEN - EINDHOVEN - HOLLAND
Sole distributors and advisory service for the U.K.: Research & Control Instruments Ltd, Instrument House, 207/215, King's Cross Road, London WC1

STABILISED A.C. MAINS UNIT

PROV. PATENT 13512/54

This Unit was developed to meet the demand for an alternative source of supply for the SP500 Spectrophotometer, thereby replacing the heavy capacity batteries which have previously been essential to give satisfactory operation.



for use with

UNICAM SP500 SPECTROPHOTOMETER

CAT. NO. E 1151

Delivery Stock

The degree of stability obtained is such that the readings of the Spectrophotometer are not affected by variations of ±50% in the supply voltage, and are also independent of the frequency changes.

Dimensions: 17¾ in. × 9½ in. × 9 in.

Weight: 34½ lb.

WRITE NOW FOR FULL DETAILS DORAN

A MEMBER OF THE DERRITRON GROUP

DORAN INSTRUMENT CO. LTD.

MEMBER OF THE DERRITRON GROUP

24 UPPER BROOK STREET, MAYFAIR, LONDON, W.1 Tel : HYDE PARK 2291

Da1826IN

"ESCORUBBER" RUBBER SILICONE RUBBER and PLASTIC BUNGS

In various qualities and many sizes

"E.R.L." HOLDERS for TEST TUBES, AMPOULES, BOTTLES, etc.

In 8 sizes either in black synthetic rubber, orange plastic or softer red organic rubber

"ESCORUBBER" RUBBER and SILICONE RUBBER BOTTLE CAP LINERS

Made in many standard sizes or to specification

"E.R.P." PLASTIC TUBING

Non-pyrogenic and non-toxic for Blood Transfusion, sterilizable at 120° C., flexible, excellent for general laboratory and hospital work, milk, various chemicals, hot water, etc.

"ESCORUBBER" SILICONE RUBBER TUBING

Non-toxic, translucent, will withstand temperatures up to 200/250° C.

"H.R.S. S." PLASTIC TUBING

Semi-elastic, non-toxic, translucent, sterilizable at 120° C., excellent for various foodstuffs, milk and many other laboratory, hospital and industrial applications

"E.R.L." RUBBER FILTERING CONES for BUCHNER FLASKS

In sets of 6 at 22s. 6d. per set

"ESCORUBBER" RUBBER and SILICONE RUBBER SHEETS

Made in various qualities and many sizes

"E.R.L." SILICONE RUBBER COVERED MAGNETS for MAGNETIC STIRRING

1" at 7s. 6d. each
1½" at 9s. 6d. each
2" at 12s. 6d. each

"ESCORUBBER" RUBBER and SILICONE RUBBER RINGS, SLEEVES and GASKETS

Several standard sizes or made to specification

"E.R.L." RUBBER PIPETTE TEATS

Extra heavy, in 7 colours for identification purposes approx. 2½ c.c. and 5 c.c.

"E.R.L." DISPOSABLE PLASTIC BLOOD and SALINE TRANSFUSION SETS

Advanced designs at competitive prices

"ESCORUBBER" CLOSURES for BLOOD and SALINE SOLUTION BOTTLES

Ref. No. P2—made in high quality rubber, and used extensively by many well-known hospitals

"ESCOPLASTIC" PLASTIC PIPETTE TEATS

with remarkable resistance to many chemicals

Size No. 1 @ 60/- per gross
Size No. 2 @ 75/- " "

"E.R.L." APRON RUBBER BUNGS

Designed for use with infectious materials

"E.R.L./52" "ROUX" BOROSILICATE GLASS FLASKS

Specially selected for high standard tissue culture work

"ESCOPLASTIC" DISPOSABLE INJECTION APPLICATORS

For effective and inexpensive injection of small volumes of liquids

ESCO (RUBBER) LTD.

Manufacturers of Rubber, Silicone Rubber and Plastic Products

34/36, SOMERFORD GROVE · LONDON · N.16

VACUUM TECHNIQUES

There are many different methods of leak detection but none, we think, can compare with our Halogen Leak Detector. Precise location of leaks down to 10^{-2} lusecs.

For full details write to

LEYBOLD-ELLIOTT LTD.,
MANOR WAY, BOREHAMWOOD, HERTS

NATURE

No. 4764 SATURDAY, FEBRUARY 18, 1961 Vol. 189

CONTENTS

	Page
University Administration in Great Britain	517
Evolution of the Flower. By J. Parkin	519
History of Western Ideas. By Dr. D. Thomson	520
A Text-book of Surface Chemistry. By Prof. N. K. Adam, F.R.S.	521
Advances in Organic Chemistry. By Dr. D. W. A. Sharp	521
Graphite: an Ideally Imperfect Material. By Dr. G. E. Bacon	522
Animal Behaviour. By Dr. A. D. Blest	522
The Possibility of Therapeutic Applications of Beams of Negative π-Mesons. By Dr. P. H. Fowler and Dr. D. H. Perkins	524
The Perception of Speech	528
Obituary: Prof. H. T. S. Britton. By Dr. S. J. Gregg	529
News and Views	530
The 1961 Exhibition of the Institute of Physics and the Physical Society. By G. R. Noakes	535
Calorie Balance in Man. By Dr. J. V. G. A. Durnin	536
Water in Australia	537
Political and Economic Planning in Pakistan	539
Radio Research during 1959. By Prof. W. J. G. Beynon	539
Safeguarding Health in London	540
Research in the Social Sciences. By T. H. Hawkins	541
Training Engineering Graduates	542
Poliomyelitis	542
Upper Winds over the World. By Dr. A. W. Brewer	543
Direction of the Geomagnetic Field during the Triassic Period in Siberia. By Dr. E. R. Deutsch and N. D. Watkins	543
Geological Reconnaissance in Victoria Land, Antarctica. By B. C. McKelvey and P. N. Webb	545
Spectral Characteristics of Aggregated Chlorophyll and its Possible Role in Photosynthesis. By Seymour Steven Brody and Marcia Brody	547
Polymer Monolayers. By J. M. Hammond, Monica H. Williams and W. G. P. Robertson	549
High-Yield Crystallization of Urease from Jack Bean. By Dr. Kiyomichi Hanabusa	551
Inhibition of the Multiplication of Influenza Virus by Aniline Derivatives of the Francis Inhibitor. By Dr. I. Hollós	553
Action of *Vicia faba* on Erythrocytes: Possible Relationship to Favism. By Dr. J. E. Bowman and Dr. D. G. Walker	555
A Gene determining Presence or Absence of ε-N-Methyl-Lysine in *Salmonella* Flagellar Protein. By Dr. B. A. D. Stocker, Dr. M. W. McDonough and Dr. R. P. Ambler	556
Cytology of Cells which synthesize Protein. By M. S. C. Birbeck and Dr. E. H. Mercer	558

(Continued overleaf)

a passage to Holland . . .

. . . or it could well have been Basle, Capetown, Manchester, Melbourne, Uppsala or Trail B.C.

In Universities and Industrial Research Laboratories the world over the SP100 Infrared Vacuum Spectrophotometer is providing a combination of high resolution, extreme quantitative accuracy, speed and reliability otherwise unobtainable in one instrument.

Write for the comprehensive brochure giving full details of this remarkable, versatile and powerful spectroscopic tool.

UNICAM

SP 100

Infrared Spectrophotometer

is the complete answer to the most exacting demands of present day analysis

UNICAM INSTRUMENTS LIMITED · ARBURY WORKS · CAMBRIDGE · ENGLAND

(U.201)

LETTERS TO THE EDITORS

RADIOASTRONOMY — Page

Secular Variation of the Flux Density of the Radio Source Cassiopeia A.—Dr. J. A. Högbom and Dr. J. R. Shakeshaft 561

RADIOPHYSICS

A New Method for the Calculation of $N(h)$ Profiles from Ionospheric $h'(f)$ Curves.—H. Hojo . 562

PHYSICS

Influence of an Electric Field upon the Heat Transfer from a Hot Wire to an Insulating Liquid.—Dr. P. Keith Watson 563

Electron Microscopy of Crystal Lattices: an Anomalous Effect.—Lewis T. Chadderton . 564

Magnetic Energy.—Prof. E. G. Cullwick; Prof. V. C. A. Ferraro 565

METALLURGY

Some Properties of Scandium Metal.—P. G. Mardon, J. L. Nichols, J. H. Pearce and D. M. Poole 566

Control of Irradiation Embrittlement in Molybdenum.—D. N. Sethna, A. A. Johnson, K. J. Proud and S. S. Sheinin 568

CHEMICAL ENGINEERING

Evidence of Phase Changes in Zirconia from Thermal Etching.—P. E. Evans and G. Wildsmith 569

CHEMISTRY

Gas Chromatographic Separation of Low-boiling Hydrocarbons using Active Alumina as Support for the Liquid Phase.—Dr. I. Halász and E. E. Wegner 570

Gas Chromatographic Analysis of Permanent Gases using Standard Ionization Detector Equipment.—Dr. R. A. Landowne and Dr. S. R. Lipsky 571

α-Configuration of Fibrous Proteins.—R. D. B. Fraser and T. P. MacRae 572

BIOCHEMISTRY

Nature of Thyroxine-binding Globulin in Human Serum.—Dr. J. R. Tata 573

Influence of the Charge on a Serum Protein Molecule and its Ability to stimulate or inhibit the Phagocytosis of Bacteria by Leucocytes.—B. J. Northover 574

Synthesis of Biologically Active Cellulose Derivatives of Enzymes.—Dr. Milton A. Mitz and Louis J. Summaria 576

Distribution of Coenzyme *Q* in Rat Liver Cell Fractions.—P. Seshadri Sastry, J. Jayaraman and Dr. T. Ramasarma 577

Conversion of DL-*m*-Tyrosine to Dopamine in the Rat.—Prof. T. L. Sourkes, G. F. Murphy and A. Rabinovitch 577

Reduction of Coenzyme *Q* by Succinic Acid Dehydrogenase.—Prof. Józef Heller, Dr. Ludmila Szarkowska and Czesława Petryszyn . . 578

PHYSIOLOGY

Nervous Activity in Relation to the Respiratory Cycle.—E. W. Poole 579

Changes in Mode of Respiration as an Indication of Level of Awareness.—Dr. L. Goldie and J. M. Green 581

The Synchronous Discharge of Apocrine Sweat Glands of the Welsh Mountain Sheep.—Dr. John Bligh 582

Influence of Calcium on the Potassium-Contracture of 'Slow' and 'Fast' Skeletal Muscle Fibres of the Frog.—P. Pauschinger and Prof. K. Brecht 583

Distribution and Fate of Rose Bengal.—Dr. V. Bocci 584

HÆMATOLOGY — Page

Inherited Hæmoglobin Ionographic Properties in Cotton Rats.—Prof. Charles W. Foreman . 585

A New Inheritable Property of Human Sera: the InV Factor.—Dr. C. Ropartz, Dr. J. Lenoir and Dr. L. Rivat 586

Delayed Hypersensitivity to Homologous γ-Globulin in the Guinea Pig.—Dr. B. Benacerraf and Dr. P. G. H. Gell 586

RADIOBIOLOGY

Absorption of Inhaled Radioactive Water Vapour.—J. B. West and C. T. Dollery 588

Effect of Radioprotective Sulphydryl Compounds on the Oxygen Tension in the Spleen of Mice.—Dr. C. van der Meer, Miss P. W. Valkenburg and Miss M. Remmelts 588

Changes in Radioresistance of Sporulating Cells of *Bacillus cereus*.—Dr. Vladimir Vinter . . 589

HISTOCHEMISTRY

Effects of Nitrogen Mustard on the Histochemistry of Mouse Lymphocytic Leukæmia *L* 1210.—Dr. George J. Furman, Prof. G. Adolph Ackerman and Dr. Carl Cohen 591

Steroid-3β-ol-Dehydrogenase Activity in Fœtal Leydig's Cells.—Dr. Mikko Niemi and Dr. M. Ikonen 592

PATHOLOGY

Mast Cells and Fibrinolysin.—Dr. Norman Ende and Dr. Joseph V. Auditore 593

Pyridine Nucleotide Metabolism in Heliotrine Poisoning.—Prof. G. S. Christie, R. N. LePage and Margot J. Bailie 593

ANATOMY

Properties of Stressed Bone.—Prof. C. J. Dreyer 594

BIOLOGY

Transfer of Tolerance to Skin Grafts in F_1 *C57Bl* Inbred Mice.—Anna Skowron-Cendrzak . 595

Perfect Stages of *Fusarium oxysporum* and of *Fusarium solani* f. *pisi* still Unknown.—Dr. William C. Snyder and James V. Alexander . 596

Effect of 6-Methoxybenzoxazolinone on the Growth of *Xanthomonas stewartii* (Erw. Smith) Dowson and its Presence in Sweet Corn (*Zea mays* var. *saccharata* Bailey).—N. J. Whitney and C. G. Mortimore 596

Location of Manganese taken up in Short-term Absorption by Oat Roots.—E. R. Page . . 597

Relationship of Radiation, Leaf Area Index and Crop Growth-Rate.—W. R. Stern and Prof. C. M. Donald 597

Possibility of Fixation of Atmospheric Nitrogen by the Rice Plant.—Dr. M. G. R. Hart and Dr. E. H. Roberts 598

ENTOMOLOGY

Enzymic Glucoside Synthesis in Locusts.—Dr. J. N. Smith and Helen B. Turbert . . . 600

Fate of Aldrin and Dieldrin in Locusts.—A. J. Cohen and Dr. J. N. Smith 600

BACTERIOLOGY

Lipolytic Activity of Some Anaerobic Bacteria.—C. Gonzalez and G. Sierra 601

Greater Susceptibility to *Mycobacterium johnei* of *C.57* Black Mice, when compared with *CBA* and Swiss White Mice.—Dr. R. L. Chandler . . 602

The Host-Range of a *Streptomyces aureofaciens* Actinophage.—R. Weindling, H. D. Tresner and Dr. E. J. Backus 603

GENETICS

Morphological Separation of Cytological Races in *Ranunculus ficaria* L.—Dr. V. H. Heywood and Dr. S. Walker 604

CHAPMAN & HALL

* *Ready 27 February* *

SELECTED PAPERS ON

STRESS ANALYSIS

Presented at the Institute of Physics
Stress Analysis Group Conference—Delft 1959

Altogether 51 papers were discussed at the conference. In this volume, 18 papers are printed in the forms in which they were presented and in their original languages, together with summaries in the three languages of the conference. An English résumé has been prepared of the remaining 33 papers. This is followed by a list of titles and authors with their addresses, so that further information on the topics covered by the résumé can be obtained from the authors. *Illustrated. 50s. net*

*

A new Translation from the Russian

THE STRUCTURE OF GLASS

(Volume Two)

Proceedings of the Third All-Union Conference on the Glassy State, Leningrad, November 1959

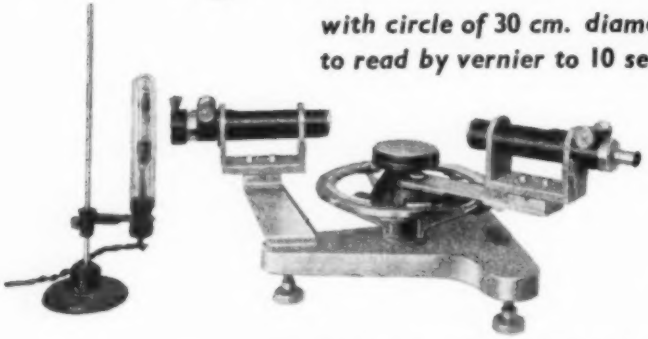
This volume presents a complete account of research work on the glassy state since the previous conference in 1953. The most modern optical, spectroscopic, and electrical techniques were used in studying the structure of glass in all its aspects, and the results are interpreted in the light of modern physical theories of the solid state. *Illustrated. 200s. net*

37 ESSEX STREET, LONDON, W.C.2

PRECISION BS INSTRUMENTS

Spectrometer No. 3

with circle of 30 cm. diameter divided to read by vernier to 10 seconds



PRISM TABLE rotates and is fitted with levelling screws

TELESCOPE AND COLLIMATOR have centring adjustment

EYEPIECE is of 25 mm. separation

Our technical staff are always available to give help or advice on any of our instruments or their uses.

Bellingham & Stanley Ltd.

DEPT. N, 71 HORNSEY RISE, LONDON, N.19

PHONE: ARCHWAY 2270

Sole distributors in U.K. for Schott Monochromatic Interference Filters

UNIVERSITY ADMINISTRATION IN GREAT BRITAIN

IN its recent policy statement "Science and Education"*, the Association of Scientific Workers suggested that there is to-day a lack of contact between the universities and the industrial and government research organizations, and that co-ordination of the scientific effort of the universities with that of government and industry is only likely to be achieved by resolute and vigorous action. Looking essentially to a Royal Commission as the best method of achieving this, the Association suggests further that the time is ripe for a searching examination of the value of the traditional methods of science teaching and research in the universities in the context of the present and future needs of Great Britain. Such an inquiry, moreover, might also consider ways of ameliorating the present intensive competitive specialization in sixth forms of schools resulting from the existing scholarship system.

The Association is fully aware that university expansion should be considered in relation to the expansion of technical education also, both of the technical schools and colleges and of the colleges of technology; and, specifically, it recommends the elaboration of a national plan for the co-ordinated development of universities, technical colleges, teacher-training colleges, agricultural colleges, and colleges of art and music in Britain. This is as far as the statement goes; it does not go into the question of university government and administration. This aspect was raised at the Conference of Universities of the United Kingdom in London last December, when there was some discussion, and also disagreement, about the relations of teaching and research. There was firm support, however, for full participation of the academic staff in governing university institutions, and the dangers of external influence were stressed rather to the extent of over-shadowing the importance of securing local support and understanding and of the value of the independent advice and experience which could be drawn from outside the academic world, on which Sir Arthur Rucker rightly laid stress in his recent report.

Some re-assurance on university autonomy, particularly in respect of the new institutions, was offered to the Conference by Viscount Mackintosh of Halifax, but this question of university administration has been brought forward in recent issues of *Science and Freedom*†. The question is clearly one which lies well within the terms of reference of the Robbins Committee, and it is essential that some clear and constructive thought should be given before the pattern of university expansion and the interrelations of university institutions with other institutions of higher education are determined. Indeed, such thinking may well be the essential condition of the continuance of academic autonomy in an age in which university institutions are increasingly dependent upon public finance.

Some four years ago, in an article entitled "Self-Government in Modern British Universities", Sir Eric Ashby suggested that it is essential for academic freedom in a university that the academic staff should have *de facto* control of the admission and examination of students; the curricula for courses of study; the appointment and tenure of office of academic staff; and the allocation of income among the different categories of expenditure. The last-named, however, constitutes the real difficulty, and Sir Eric, who recognized freely the important part that laymen on university councils have taken in defending academic freedom, pointed out that, in speaking of the responsibility of the university council for the wider interests of the university in the community, he does not mean the interests of the community in the university. Furthermore, academic freedom depends less on the formal constitution than on the spirit in which it is interpreted in practice by the governing body, in collaboration with the academic staff.

These points, and the further one that the main direction of flow of new ideas and proposals, in contrast with the flow of finance, is from below upwards and not in the reverse direction, are to be remembered in considering the controversy that has been provoked by Dr. A. P. Rowe's broadcast and his paper in *Science and Freedom*, entitled "The Problem of Freedom and Efficiency in Universities", on which that broadcast was largely based. Equally they have reference to the discussion on the place of the independent research institution arising out of an earlier broadcast talk by Prof. A. H. Cottrell, entitled, "Scientists: Solo or Concerted", which was published in *The Listener* of September 15.

Particularly in his broadcast talk, Dr. Rowe challenged the existing pattern of research and teaching in British universities, and the appropriateness of some of the arrangements made in the past for much smaller numbers of students, for the conditions of to-day when the numbers of students are not only much larger but also there are liable to be fewer students with first-class minds or from homes with a tradition of learning or culture. Supporting Baroness Wootton's suggestion in the House of Lords debate on May 11 that some inquiry should

* Science and Education: a Policy Statement by the Association of Scientific Workers. Pp. 16. (London: Association of Scientific Workers, 1960.) 1s.

† Committee on Science and Freedom. Bulletin No. 16: Freedom and Efficiency: Problems of University Administration in Britain and the Commonwealth. Pp. 32. (Manchester: Committee on Science and Freedom, 818 Wilmslow Road, 1960.)

be made into the distribution of teaching and research among the staffs and faculties in different universities, he urged further that university research should be located primarily in institutes associated with universities and not in self-contained university departments. In addition, he suggested that more attention should be given both to the quality of university teaching and to the needs and treatment of the ordinary student.

It is from a re-assessment of the tasks of universities in Britain along such lines that Dr. Rowe proceeded to discuss the administration of a university. He visualizes a university organized flexibly, with interchangeable staffs and common social, library and other facilities, to undertake the three tasks, first, of teaching a majority of earnest, intelligent but not brilliant students, mostly from homes with little tradition of learning; secondly, of dealing with more senior students, capable of standing on their own feet and benefiting from contact with great minds, and who need advanced courses and training in research methods; and thirdly, with research, calling for continuity of effort and team-work. To achieve these ends, Dr. Rowe calls for the elimination of departmentalism and for a real measure of authority above the professorial level. This he would place in the hands of a very few able and experienced academic men with few other duties and appointed for a long period.

There is considerable foundation and support for the strongly held belief in the interdependence of research and teaching, but it will be remembered that the balance between teaching and research was one of the questions which Lord Simon of Wythenshawe suggested for inquiry by a Royal Commission or special committee. Whether it will be examined by the Robbins Committee remains to be seen, but Dr. Rowe has the support of Lord Beveridge and others in suggesting that more attention needs to be given to teaching. Nothing but good could come from any steps taken to emphasize the teaching functions of the university and to raise the standard of teaching, either by the revision of courses, the introduction of new methods, or by supervision of untrained and inexperienced teachers.

Nevertheless, Dr. Rowe has pointed out a number of weaknesses, which require administrative action for the most part if they are to be corrected, whether or not a change in the administrative structure of the universities is involved. A system which ensured that teaching ability drew its recognition and reward, as well as distinction in research, would of itself assist in putting university teaching back into its proper place; but Dr. Rowe merely distinguishes between learning and teaching, and on this point the analysis should go deeper. In intellectual work, both in the communication of knowledge and in the discovery of new knowledge, it is quality that counts; and in the expansion of university education, too great care cannot be taken to safeguard the pursuit of excellence. The outstanding danger is that of mediocrity. Great thinkers and scholars bring inspiration and stimulus not merely to the little cluster of research workers immediately around them, but also to successive generations of students in the whole university.

What seems clear enough is that some investigation of the quality of the research work being done in university laboratories, particularly with reference to the resources available and in comparison with that being done in the research institutes, of both independent foundations and of the Department of Scientific and Industrial Research, might well be worth while. Similarly, it would seem that teaching methods and courses should be re-examined in the light of the increasing numbers of university students of moderate ability with little tradition of learning. The second inquiry might appropriately be made by the individual universities, and the problem appears to be well to the front in the thinking of those responsible for the organization of the new universities in Britain. The first, however, calls for wider and independent examination, such as might, for example, be appropriately initiated by the Minister for Science or his Advisory Council for Scientific Policy. It obviously lies rather outside the scope of the Robbins Committee, though inquiry might well lead to findings with important administrative implications—as indeed is foreshadowed in the last report of the Advisory Council on Scientific Policy. Moreover, Prof. Cottrell has pointed out that the problems of administration of the research institute are very similar, and the implications are important if waste of national resources is to be avoided.

Despite, however, the approval given by Sir Arthur Rucker in his recent report to certain aspects of university administration, there appears to be a *prima facie* case for an independent examination of the whole structure of university administration in the light of the needs of to-day. Apart from the internal stresses that arise inevitably out of the sheer numerical size of expanding universities, the problems of adjusting the claims of teaching and research, those of research between the different disciplines and fields of knowledge, and particularly the relation between available national resources and what is being done elsewhere, either in other universities or in government or independent research institutions, are growing in complexity. It is already clear that more attention will have to be given to university co-operation, and increasingly the demands of university administration call for the separation of policy and executive management. This is not to suggest that a solution is to be found by imparting unmodified the type of organization which characterizes large, efficient and progressive business organizations. It is perhaps worth noting that the Committee under the chairmanship of Sir David Hughes Parry which reported a year ago on the New Zealand Universities (see *Nature*, **187**, 107; 1960), besides recommending the establishment of a university grants committee, suggested governing bodies for the new universities of not more than twenty,

including eight lay members, four of high standing in the Dominions and nominated by the Governor-General, and four co-opted by the governing body itself from those interested in the work and progress of the university and likely to give weight and authority to the university in the community. While the governing body has the final decision, it has full powers of delegation; further, the rights of the professorial board to be consulted on and to discuss any matter relating to the university, as well as its duty to advise the governing body, are emphasized. The Ashby Commission on Post-School Certificate and Higher Education in Nigeria takes a very similar line; its chapter in university government recommends a national universities commission, similar to the University Grants Committee in Britain, and emphasizes the importance of both the academic representation and the lay element on the governing bodies of Nigerian universities, as well as insisting on the undisputed autonomy of these governing bodies.

The whole subject deserves some careful and perhaps independent study and hard and creative thought. Universities, and the nation, might well benefit if a few university administrators found their way to the Administrative Staff College, though little might result unless the organization of their universities enabled them to give effect to measures which would eliminate waste and result in more effective use of highly trained staff; initially such measures usually tend to involve additional expenditure on technicians or auxiliary staff or equipment, and such expenditure, even if comparatively trivial, is not always readily sanctioned under existing arrangements as the University Grants Committee well knows. Lord Simon of Wythenshawe, to whose original suggestion of a Royal Commission the appointment of the Robbins Committee was ultimately due, had such administrative matters clearly in his mind, though he referred more specifically to the need for some means of co-ordinating the work of universities and that of other institutions for higher education. Even if the Robbins Committee does not itself look at these problems of the government and administration of universities in some detail, its report should leave no room for doubt as to the importance of such a full inquiry, or where the responsibility for initiating, as a matter of urgency, such an investigation most appropriately rests.

EVOLUTION OF THE FLOWER

Die Evolution der Angiospermen

Von Prof. Dr. Armen Takhtajan. Pp. viii + 334. (Jena: Gustav Fischer Verlag, 1959.) 44.90 D.M.

THIS is a comprehensive work in German dealing with the flowering plants as a whole as well as in detail. The author is a Russian—strictly speaking an Armenian—and yet can write lucidly in languages other than his own. I have had letters from him in quite good English, making one blush at one's feeble attempts to communicate in any other language than one's own.

The opening sections deal with matters applicable generally to phylogeny—such as progressive, adaptive evolution and specialization. Here he uses a term new to me—'heterobathmie'. It means that one set of organs may advance while others remain static or even degenerate. This in a way may be considered axiomatic, but is not always taken into account in discussing phylogenies.

Some stress is also laid on 'neoteny' (pp. 25 and 143)—a somewhat new term as applied to botany, though it has been in use for some time in zoology—meaning the possibility of evolution advancing from juvenile stages with the elimination of the adult ones. Takhtajan thinks neoteny might help in explaining the very compressed type of gametophyte to be found in the angiospermous embryo sac. He has elaborated the idea of neoteny in essays of a somewhat philosophical nature recently translated from Russian and published in English. Perhaps he is inclined to overstress neoteny, but to make any new view impressive and to invite criticism an overstatement is not without its advantages.

After the general section, the work proceeds to discuss individually the various parts of the angiospermous plant from the evolutionary point of view. Sections are devoted to stem, leaf, conducting systems, flower, inflorescence, pollination, anther, embryo sac, male and female gametophytes, seed, fruit and aril. He enters into great detail regarding the structure of the pollen grain and its value in phylogeny.

Though a believer in the woody angiosperm preceding the herbaceous, he has a section on the passage back of the herb to the shrub. He points out that this would seem to have occurred in the five families which he mentions (p. 38). In all such cases it is necessary to emphasize that the reversion should be revealed structurally, particularly in the vascular elements. Evolution does not revert backwards morphologically, but does at times physiologically, that is, functionally. Hutchinson's second edition of his *Families of Flowering Plants* had only just appeared and apparently was not in time for Prof. Takhtajan to comment on the former's rigid division of the Dicotyledons into two main lines of woody and herbaceous forms. These he keeps as separate evolutions from non-existing ancestors, and, now in his second edition, is bold enough to name the Lignosae and Herbaceae respectively. It would be going outside the limits of this review to comment further on this far-reaching division of the Dicotyledons, but it is a matter that the systematists will have to take seriously into account.

The third part of the work is systematic, taking the orders in succession with descriptions of each, and appending to them the families they each include. The author further groups the orders into a higher category termed 'Überordnung'.

A few points in the scheme of classification, which is largely based on those of Bessey, Hallier and Hutchinson, may be mentioned. The genus *Paeonia* is now generally recognized to be worthy of a family to itself, Paeoniaceae. Hutchinson keeps it in the order Ranales; but Takhtajan widens the gap, as it were, placing it in the order Dilleniales. *Nelumbo*, the lotus lily, is removed from the Nymphaeales and given an order to itself, the Nelumbonales. One distinction from the other water lilies is shown in the structure of its pollen grain. The willows and poplars, the Salicaceae, always difficult to place,

Takhtajan has put near the tamarisks and daphnes. Hutchinson still keeps them near the catkin families.

The author appends to the systematic descriptions a linear list of orders and families. On running through this list one is drawn up sharply with such unfamiliar names as Brassicaceae, Fabaceae, Apiaceae, Lamiaceae, Asteraceae, Poaceae, and Araceae in place of such time-honoured ones as Cruciferae, Papilionaceae, Umbelliferae, Labiatae, Compositae, Gramineae, and Palmae. One can see the reason for this. The old familiar names, except one, do not end in the customary '-aceae'. Without doing away with the old names entirely, could not each be extended by the interpolation of 'Ac', thus making them all end in '-aceae'? It is now generally admitted that the old Leguminosae is better split into three separate families. Hutchinson has the three now grouped under the order Leguminales, but Takhtajan under Fabiales. Would not the former be better, thus preserving the old name legume, so long associated with this group of plants?

It seems to me that some uniformity should be adopted regarding the above families. This might be settled at the next International Botanical Congress; and I would suggest that if a committee be formed for discussing nomenclature the horticulturist should be consulted as well as the systematist.

A word of appreciation must be said for the very full bibliography given. This alone makes the volume very desirable. There are also three quite useful indexes. In fact the text is so well documented that a work of this character in English would make a desirable advanced text-book for students.

The author is cautious in not putting forward any new speculations as to the solution of the still great problem, the origin of the Angiosperms. Reading between the lines and from correspondence, his inclination is towards the Magnolian–Bennettalean view as to the primitive features of the flower. Engler's main classification and the Caytonialian speculations are scarcely mentioned, looking as if they were now outmoded. J. Parkin

HISTORY OF WESTERN IDEAS

The Western Intellectual Tradition from Leonardo to Hegel

By Dr. J. Bronowski and Dr. Bruce Mazlish. Pp. xviii + 522. (London: Hutchinson and Co. (Publishers), Ltd., 1960.) 30*s*. net.

THE authors set out to expound the history of Western thought from the late-fifteenth to the early-nineteenth centuries on three principles which, they claim, are fundamentally new. One is comprehensiveness—"we are interested in the whole spectrum of the mind"; the second is that ideas should be related to events; the third is that ideas should be studied through the men who first conceived them. The combination of these three principles, which they call triangulation, is intended to produce the "integration of intellectual history" and so make a coherent relationship between science and the humanities. They lay high claim to originality in so doing, and their preface is unusually full of self-congratulation for being pioneers in such a task.

The result, in view of these claims, is nevertheless conventional. They do not, fortunately, attempt to cover "the whole spectrum of the mind", for they say little about theology, moral philosophy, æsthetics, literature and drama, the fine arts, or indeed any realm of thought other than the conventional realms of political, social, economic and scientific thought. Their other two 'principles' are certainly not original, and they adopt the episodic chronological method already only too common in histories of political thought: some biographical facts, summaries of a man's ideas in relation to his life and times, some generalizations about his importance, above all for our own day. Their prime aim, to integrate scientific thought with social and political thought, cannot be achieved by merely including a chapter on the scientific revolution alongside those on Leonardo and Machiavelli, or one on the Royal Society along with those on Hobbes, Locke and Descartes. Nor have the historians of ideas, of whom they speak so contemptuously, been so unaware of the influence of a Galileo, a Newton, or a Watt. The remark of Sir Charles Snow which they quote with such warm approval can scarcely go on record as one of his more felicitous or accurate statements: "The steam engine helped to shape the modern world at least as much as Napoleon and Adam Smith, *but only rarely do the historians admit the fact*". The book ends, moreover, around 1830, just when the authors' self-imposed task would become really important but also extremely difficult.

Most of the time the historical categories of the book are entirely conventional—superficial generalities about "rising middle classes", or about scientific, industrial, political 'revolutions'. Its historical judgments are at times, indeed, out of date. Although footnote homage is duly paid to the late Sir Lewis Namier, the text (p. 366) still asserts that George III "was determined to impose an absolute rule on America as on England". When more original the authors are apt to be extravagant. The resistance to Charles I after 1630 is described as "the first major revolution in the world" (p. xvii). The assertion that "the experience of the French Revolution and of Napoleon, the philosophy of a Hegel, marks (*sic*) the transition from dynastic empires and tradition to nation states and charismatic authority" (p. xvi) leaves inexplicable the next hundred years of European history, which saw the creation of new dynastic empires in France and Germany and their cheerful survival in Austria–Hungary, Russia and Turkey.

Nor are the authors consistently true to their avowed method. How can they hope to explain the ideas of the late-seventeenth century, including their all-important scientific revolution, without giving much more systematic attention to events and conditions in the Netherlands, or a clearer picture of the English Civil War? They are shaky on economic history (even apart from allegations that historians neglect the steam-engine), and whether on enclosures in England or serfdom in Europe they commit vague and misleading assertions. They (or their indexer) confuses Robert Walpole with Horace: and to speak of Rousseau's "one-party view" is to misunderstand a vital part of his theory. On the Royal Society and the Lunar Society of Birmingham the authors have much to say that is interesting but scarcely original.

However, when all these substantial defects have been noted, the book has its uses and its value. It is, on the whole, a successful piece of intellectual regurgitation. It is written in a lively, easy style, confident if sometimes over-confident. It has excellent bibliographical notes and admirable brief

summaries of the main historical controversies. It directs attention, at least, to the need to widen and deepen and experiment in the study of intellectual history. As a piece of popularization it is enterprising, efficient, and as good as most. It is not more than that.

D. THOMSON

A TEXT-BOOK OF SURFACE CHEMISTRY

Physical Chemistry of Surfaces

By Arthur W. Adamson. Pp. xiv + 629. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.) 96*s*.

PROF. ADAMSON has written a very useful text-book of surface chemistry, well balanced, full, and as up to date as anyone is likely to achieve in these days of over-voluminous and often hasty publication. It covers most of the field, including chapters on capillarity, the thermodynamics of liquid-vapour interfaces, surface films on liquids, electrical aspects of surfaces, and long-range forces. Five chapters deal with solid surfaces, one being a brief introduction to chemisorption and catalysis; and in three more, various practical applications, including wetting and detergency, flotation of minerals, emulsions and foams, and friction and lubrication, are competently discussed.

Very sensibly, the author has made good use of several earlier books, and he has added, and usually succeeded in satisfactorily incorporating, a very large amount of later work. The book is written primarily for first-year graduate students in American universities, but it should also be valuable to senior undergraduates and to anyone desiring to learn the principles, and many of the details and applications, of the subject. Many, indeed, who have carried out considerable research on surfaces can learn much from this book, in those parts of surface chemistry in which they are not specialists.

The book is also remarkably clearly written, with numerous useful analogies: for example, the difficulty of defining the area of a surface is compared with the difficulty of deciding what should be taken as the coast-line of Maine. There are a number of problems for the reader to work out at the end of many of the chapters: some of these are ingenious, and admirably suited to test the student's understanding.

I have few criticisms: perhaps there are more mistakes in historical matters, assignment of priority in discovery, dates, and spelling of names, than might have been expected: but once detected, these can easily be rectified in future printings. In places, particularly in discussing heterogeneous catalysis, he follows the modern fashion of attaching names to theories and mechanisms, and these are not always those of the originators. Few people realize that it was Langmuir who, in 1922, published quite detailed and well-worked-out kinetics of catalytic oxidation, assuming reaction between adsorbed atoms of oxygen and molecules colliding from the gas phase: yet in this book, as unfortunately in much current literature, another name is given to this mechanism while Langmuir's name is attached to a mechanism which, so far as I am aware, he did not advocate. Too frequent attachment of names, according to current and sometimes local fashion rather than historical fact, renders a large majority of papers unreadable to anyone outside the immediate circle of specialists to which the author happens to belong, and should be avoided if possible in text-books.

Apart from these quite minor blemishes, Prof. Adamson has made a most valuable contribution to the literature of, and education in, surface chemistry, and deserves hearty congratulation. The same cannot be said of the publishers, who have fixed a price that may well put the book out of reach of large numbers who would profit by owning it.

N. K. ADAM

ADVANCES IN INORGANIC CHEMISTRY

Advances in Inorganic Chemistry and Radiochemistry

Vol. 2. Edited by H. J. Emeléus and A. G. Sharpe. Pp. viii + 392. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 12 dollars.

THE titles of the reviews in this volume are as follows: "Stereochemistry of Ionic Solids", by J. D. Dunitz and L. E. Orgel; "Organometallic Compounds" by J. Eisch and H. Gilman; "Fluorine-containing Compounds of Sulphur" by G. H. Cady; "Amides and Imides of the Oxyacids of Sulphur" by M. Becke-Goehring; "Halides of the Actinide Elements" by J. J. Katz and I. Sheft; "Structures of Compounds Containing Chains of Sulphur Atoms" by O. Foss; "Chemical Reactivity of the Boron Hydrides and Related Compounds" by F. G. A. Stone; and "Mass Spectrometry in Nuclear Chemistry" by H. G. Thode, C. C. McMullen and K. Fritze.

From the long-term point of view, the most important articles are probably the first two, which attempt explanation as well as summary. The chapter by Dunitz and Orgel should be read by anyone professing a knowledge of structural inorganic chemistry. Three of the other chapters are devoted to various aspects of the chemistry of sulphur and reflect the current great interest in the chemistry of the elements of the second short row of the Periodic Table—although it is rather unfortunate that there is some overlap between the article on sulphur acid amides and a recent review on sulphur–nitrogen chemistry in *Progress in Inorganic Chemistry*. The chapter on mass spectrometry is devoted largely to the study and theory of fission yields. From the point of view of physical techniques this volume has two chapters devoted to results derived by X-ray crystallography. This should emphasize that the only absolute method of structural determination is by crystallography, and it is to be hoped that these reviews will stimulate further the interest of crystallographers in the structures of inorganic compounds.

Both in the standard of articles and of production, this volume is fully up to the high standard of the first of the series. The general state of health of inorganic chemistry is shown by its apparent ability to support both this series and the parallel series of *Progress in Inorganic Chemistry*. There is a risk that there will soon be almost as many chemists writing reviews as are carrying out original work, but at the moment *Advances in Inorganic Chemistry and Radiochemistry* is proving an extremely useful and informative series.

D. W. A. SHARP

GRAPHITE: AN IDEALLY IMPERFECT MATERIAL

Graphite and Its Crystal Compounds

By Prof. A. R. Ubbelohde and F. A. Lewis. Pp. xii + 217. (Oxford: Clarendon Press; London: Oxford University Press, 1960.) 35*s*. net.

GRAPHITE is perhaps the best example of the fact that the regular three-dimensional structure of solids, so clearly revealed by the early work of von Laue and the Braggs, is only a first approximation to the truth. A study of its physical and chemical properties, many of which have become of great technical importance, reveals the significance of imperfections in the solid and demonstrates how far we are from possessing any refined means of measuring crystal defects.

It is against this kind of background that Ubbelohde and Lewis have written their monograph *Graphite and Its Crystal Compounds*, which brings together the vast literature on this subject for the first time. The authors do full justice to the fact that it is a wide range of materials which they are describing and not a single well-defined substance. During the past twenty years the number of technical uses and demands for graphite have greatly multiplied: for example, nuclear reactors have called for graphites with closely specified properties, such as purity, high-density and non-permeability. These needs have stimulated research by every kind of modern technique, but, as the authors say, our knowledge is still very uneven and imperfect. Their book provides a basic text as a starting point for the many physicists, chemists, engineers and others who seek to understand some aspect of graphite in relation to the wider, still imperfect, picture.

Rather more than half the book deals with graphite itself, in four chapters. The first of these is written from a crystallographic point of view, and sets out our present knowledge of 'ideal' graphite and the physical and chemical departures from this perfect model which make up the wide range of materials which are known and used. Emphasis is placed on the conception of graphite as the extreme case of the large aromatic molecule. Succeeding chapters deal with the more mechanical physical properties such as compressibility, elastic moduli and frictional behaviour and with the thermal properties and the thermodynamics of the graphite-diamond transformation. The latter discussion is followed by an account of related substances such as silicon, silicon carbide, boron nitride and borazon. Chapter 4, the longest in the book, collects together the large amount of data on electronic properties, derived from measurements of magnetic susceptibility, electrical conduction, thermoelectric power, Hall effect and optical properties.

The second half of the book deals with the chemical behaviour of graphite, as represented by the production at ordinary temperatures of the characteristic lamellar compounds (in which the carbon layers retain their identity largely unchanged) and by the conversion to volatile products at higher temperatures, sufficient to break up the bond structure, by oxidation or reaction with carbon dioxide, hydrogen or water. The lamellar compounds are classified broadly in terms of their bond structure and the electronic character of the predominating carbon macro-molecules. An account of their magnetic and electrical properties concentrates on showing how the general changes on compound formation, such as reduction of electrical resistance and of diamagnetic susceptibility, contribute to the general understanding of electron bands in graphite itself. A separate chapter is devoted to the still controversial structure of graphite oxide in which the carbon networks have probably become buckled. In the final chapter, on the complete chemical transformation of graphite, the emphasis is on the mechanism of the oxidation process, its dependence on surface and edge defects and crystalline perfection, with an eye, for example, on the development of oxidation-resistant graphites for refractories and nuclear reactors.

Throughout the book the discussion is extremely well furnished with literature references, and the list of these contains about a thousand entries, including many for 1959. The only obvious omission is the very recent work by electron microscopy which may have developed into a valuable contribution in time for a second edition, for this is assuredly not a subject where fact or interpretation will remain stationary for very long. G. E. Bacon

ANIMAL BEHAVIOUR

Animal Behaviour

By Prof. J. L. Cloudsley-Thompson. Pp. xv + 162 + 16 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1960.) 15*s*. net.

ALREADY it is traditional for books on animal behaviour to be illustrated by stylish photographs, and those accompanying Prof. Cloudsley-Thompson's text are exceptionally elegant. The text itself, unfortunately, is not of the same quality. The work is explicitly intended as a primer of animal behaviour for the non-specialist reader, and the diversity of the examples which are discussed makes for a certain freshness of approach; a discursive and imprecise presentation lessens their impact. Of nocturnal animals Prof. Thompson writes: "The carnivorous habit is less hazardous too at night, and competition is reduced when nocturnal carnivores such as beetles prey on sleeping diurnal forms such as butterflies". It is not only the layman who may be expected to find this type of generalization difficult to follow in the absence of any further exposition.

Many of the drawings appear to be merely decorative. For example, an account of phototonus in *Proctacanthus* on p. 9 is accompanied by a picture of two flies in bizarre attitudes, but the legend does not explain what has been done to them. Similarly, pp. 21–22 discuss neuro-muscular facilitation in the sea anemone, but the idealized kymograph tracings of the illustration bear no account of the method by which they were obtained. The number of different examples used to reveal the mechanisms of invertebrate behaviour precludes the adequate discussion of any one of them, and we are told little about the means by which zoologists have chosen to investigate them. This is a pity, for while controversy among behaviour workers may be highly technical, their experimental methods are often extremely simple, and of just the kind to appeal to the interested layman. The last chapter is headed "Displacement Activity and Human Behaviour", and is as superficial as its title would suggest. A. D. Blest

Mambu

A Melanesian Millennium. By Dr. Kenelm Burridge. Pp. xxiii+296+17 plates (London: Methuen and Co., Ltd., 1960.) 42*s*. net.

MAMBU, pidgin English for bamboo, is in this work a name of a prophet of a millenium in which the spirits of the dead will bring the tools and consumers' goods of a developed culture for free distribution among their descendants of the Territory of Papua and New Guinea, who were recently of modern neolithic culture. The millenarian cargo-cult described began in the Territory more than sixty years ago, and has been previously discussed by several authors, including Haddon and Chinnery, Lawrence, Mead, Williams, Hanneman and Worsley. The cult has been viewed with some distaste by missionaries such as Hanneman, who notes that it is materialistic, and its prophets have, on occasion, been arrested by the administration, as they sometimes encouraged people to take no care for their self-subsistence, to slaughter their pigs and to build large and very quickly disused houses intended for the reception of the revenants with the tools and goods. Moreover, the prophets have sometimes preached that the secret of wealth was magical and was withheld from Papuans by missionaries, administrators, traders and settlers. There has not been a grave threat in the cult. Indeed, Hanneman noted with some disapproval of it that peoples of other countries organized revolutions, elections, changes of government, strikes and the writing of books on capitalism, democracy and utopia with aims of improving living conditions. The general idea in the discouragement of cargo-cult prophets has probably been to gain time until greater facilities for technical education are made available in the Territory, and until there are more Papuan students with an Australian education returned to it.

Dr. Kenelm Burridge describes incidents of the cargo cult in the Madang district and on the Island of Manam in good literary style and with a sense of the humour of situations. In particular, he discusses myths and dreams with appreciation of them, and what he terms the triangle of administrators, missionaries and Papuans with a detailed account of their angles.

R. F. FORTUNE

Fiori delle Ande

Da Alfonso Vinci. Pp. 68 (70 illustrations). (Bari: Leonardo da Vinci Editrice, 1960.) 1,500 lire.

THIS is the first pocket flower-book, of the kind so well known to us in Europe, for the Andes and perhaps for the whole of South America. The area covered is the complex series of sierras and páramos above Mérida, in Venezuela, but many of the plants illustrated have wide distributions in the Andes. The excellent short introduction, in Italian, describing the physical features, climate, geology and vegetation zones of the region, is far above the head of the average tourist and is more suited to the highly educated traveller or trained naturalist. Following this are three coloured illustrations of the three zones, tierra caliente, templada and fría. Then come the small pictures, 66 in number and also in colour, of individual flowers. The presentation of these is not worthy of the introduction, and has obviously been put together with undue haste. Many of the plants are described as "specie non determinata" or are assigned to wildly wrong families, when the identification is obvious to any botanist familiar with this flora. Yet the author thanks two distinguished local botanists for their help. It is a pity that this attractive little forerunner has been spoiled by such haste or lack of care. Even in the introduction there is the statement that *Draba* and *Pringlea*, in Cruciferae, are represented on the Andes, in the Alps and on the remote island of Kerguelen! At the top of p. 11 the second and third lines have been transposed.

N. Y. SANDWITH

Fundamentals of Nutrition

By E. W. Crampton and L. E. Lloyd. (Series of Books in Agricultural Science.) Pp. xi+494. (San Francisco and London: W. H. Freeman and Company, 1959.) 50*s*.

IN this text-book, which is planned as an introductory course in human and animal nutrition, related disciplines are briefly discussed in an opening chapter. The first section is concerned with nutrients and composition of the animal and of foods. In five further sections the subject is developed with regard to metabolism of protein, fat and carbohydrate, the nature of vitamins and of mineral elements, experimental studies on nutrition and nutrient requirements for man and animals. The text is illustrated with simplified diagrammatic representations of metabolic pathways and other physiological processes. Reading lists are appended to every chapter to encourage the student to become aware of the expanding literature on the subject of nutrition. The book would be a useful adjunct to a course in physiology where general principles of nutrition must be taught. While it does not set out to be a complete treatise on nutrition it does provide a good background to a wider study of the subject and can be recommended as a useful introduction to a rapidly growing science.

A. M. COPPING

Socrates and the Animals

By Dr. Elena Quarelli. Translated from the Italian by Kathleen Speight. Pp. 160. (London: Hodder and Stoughton, Ltd., 1960.) 12*s*. 6*d*. net.

MANY people are sentimental where animals are concerned, and attribute to them qualities that they do not possess—even anthropomorphic. Others go to the opposite extreme and dismiss them as objects incapable of life or feeling. In this book Dr. Elena Quarelli investigates the problem whether animals possess immortal souls. She does this both philosophically and logically.

She seeks information from Ancient Greek thinkers such as Aristotle and Plato, from the Bible and official representatives of Christian teaching, and from contemporary zoologists and animal psychologists. Her own theories are backed by personal experience of animals, and her anecdotes make interesting and amusing reading.

It was impossible to limit her inquiry solely to the animal world; the problem had to be seen within the context of the universe as a whole. She studies animals in relation to the whole purpose and meaning of life, including human beings. The book therefore has a sincerely religious and deep-thinking basis.

The writer combines a sympathetic but unprejudiced approach to the problem. Her findings will delight many, and can offend none.

B. J. G. MAITLAND

THE POSSIBILITY OF THERAPEUTIC APPLICATIONS OF BEAMS OF NEGATIVE π-MESONS

By Dr. P. H. FOWLER and Dr. D. H. PERKINS
H. H. Wills Physics Laboratory, University of Bristol

FOLLOWING a recent lecture by Prof. J. Rotblat given in the H. H. Wills Physics Laboratory at Bristol, on the applications of radiations in medicine, we have been led to consider the possibility of using beams of negative π-mesons for the treatment of tumours. It is well known that a serious limitation to such treatment, when γ-rays are employed, is the heavy dosage delivered to the healthy tissue in the path of the γ-rays. A typical distribution of the variation of dosage with depth, using γ-rays from cobalt-60, is shown in Fig. 2. Even when the dosage to the healthy tissues is distributed by employing several fields, the resulting toxæmia is commonly the factor limiting the amount of radiation which can be delivered to the tumour. In this situation, it occurred to us that beams of π^--mesons would have, at least in principle, a number of decisive advantages.

From the point of view of its nuclear composition, biological tissue can be regarded as made up of hydrogen, carbon, nitrogen and oxygen. When a π^--meson is brought to rest in such a medium it may be captured by any one of these atoms. When captured by hydrogen, however, the resulting π^--mesic atom migrates a short distance in the tissue until it encounters a heavier nucleus to which the π^--meson is handed over. As a result, all the π^--mesons interact, before decaying, with one or another of the nuclei carbon-12, nitrogen-14 or oxygen-16. In such interactions, about 20 per cent of the total rest-energy of the π^--meson, that is $\sim$ 30 MeV., appears in the form of α-particles and protons, very nearly all of which have ranges less than 1 mm. in biological tissue. A further 40 MeV. is expended in breaking up the nucleus, and the remaining 70 MeV. is carried off as fast particles, mostly neutrons, many of which (60–70 per cent) will escape from the tissue without interacting. For our present purposes, it is a favourable feature that capture of π^--mesons by light elements, especially carbon-12 and oxygen-16, leads to an exceptionally large release of energy in the form of short-range α-particles as compared with nuclear capture by other elements.

The range of a π^--meson of 52 MeV. is about 10 cm. in biological tissue, the maximum depth at which it is commonly necessary to irradiate tumours in the human body. If such a beam of particles is homogeneous in energy, there will be a straggling in range of about 2·5 mm. (see Appendix). Further, the scattering in the direction of motion of the particles as they pass through tissue, due to Coulomb interactions in distant collisions with nuclei, results in a lateral dispersion of their points of arrest relative to their original directions of motion.

The root-mean-square value of this lateral deviation is about 3 per cent of the mean range (see Appendix). For a range of 10 cm. therefore, most of

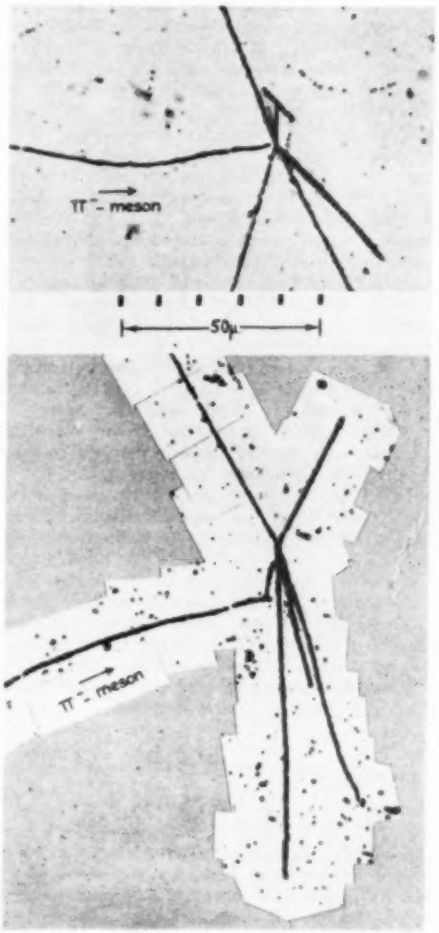


Fig. 1. Capture of negative π^--mesons: two photomicrographs of the nuclear capture of π^--mesons at rest in a nuclear emulsion. It is probable that each meson was captured by an oxygen nucleus of the gelatine. In the top example, one of the five charged secondaries is a nucleus of $^8Li_3$. This nucleus undergoes β^--decay after being brought to rest, and produces two α-particles each of $\approx$ 2 MeV. that are emitted in opposite directions. The track of the β^--particle is not shown, as it dipped steeply with respect to the plane of the emulsion
In the lower example, it is probable that the charged secondaries were 2 α-particles and 3 singly-charged particles
In sensitive emulsions such as these, discrimination between tracks due to singly- and multiply-charged secondaries of short range is poor. In emulsions of lower sensitivity, the tracks of the singly-charged secondaries with range greater than $\approx$ 20μ can be picked out with confidence. The scale in microns gives the range of the secondaries in nuclear emulsion. Ranges in tissue would be about three times greater

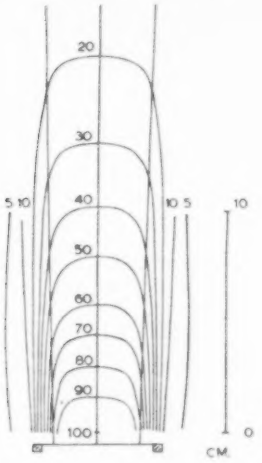


Fig. 2. Radiation field in biological tissue due to a collimated γ-ray beam from a cobalt-60 source

the points of arrest are distributed in a target area about 2 cm.² normal to the axis of the beam. The essential point emerges that the effective volume irradiated can be made less than the minimum volume of a tumour that it is usually considered desirable to treat.

In order to display the advantages of such a beam of π^--mesons, we show in Fig. 3 a calculated radiation field due to an initially parallel beam of these particles of energy 52 MeV. (range 10 cm. in tissue); the results may be compared with the computed field due to γ-rays in Fig. 2. The field produced by a proton beam of the same range is included. In each case, the beam at entry has a circular cross-section of area 2·2 cm.². In making the calculations, we have taken into account: (i) the change in loss of ionization of the beam as a function of depth; (ii) the effect of charged and neutral particles produced in the nuclear interactions of π^--mesons at the end of their range; (iii) the effect of the nuclear interactions in flight of the beam particles; and (iv) the effects of scattering and straggling on the dispersion of the beams.

In each case, no account was taken of the presence of other particles in the beam. In practice, a π-meson beam will contain an appreciable contamination of μ-mesons, electrons and neutrons, but we consider their effects could be made small.

In Fig. 3, the contours refer to the losses of ionization energy in rads (1 rad corresponds to an energy loss of 100 ergs/gm. in production of ion pairs). In order to obtain a numerical estimate of the distribution of the actual biological damage associated with this ionization, it is necessary to assume values for the relative biological damage per unit loss of energy, for the various radiations. This factor of relative biological efficiency is taken as unity for 220-keV. X-rays. It depends on the rate of loss of energy of the ionizing radiations, which are different in different regions of the radiation field. Along the path of the beams, the ionization is produced mainly by lightly ionizing particles, for which the relative biological efficiency will certainly be close to unity. In the region where the π-mesons are brought to rest, the ionization is mostly produced by heavily ionizing particles (mainly α-particles), for which the average value of the relative biological efficiency may be much higher, possibly about 6. At appreciable distances from the axis of the beam, the ionization is due to collisions of neutrons, for which the value of the relative biological efficiency is likely to be between 1 and 3. The details of the distribution of radiation damage will therefore depend on the sensitivity of the relative biological efficiency to the density of ionization of individual particles.

Unfortunately, there is at present no precise information on the values for relative biological efficiency of the different particles for the particular irradiation problem presented by the therapeutic treatment of tumours: a treatment which requires the destruction of practically all cells within a certain volume. For example, the U.S. National Bureau of Standards, in connexion with radiation protection[1], has recommended, for α-particles of energy a few MeV., a value of about 15. Snyder and Neufeld[2] have computed curves based on these recommendations for the radiation damage for various types of particles. On the other hand, direct measurements have been made by Storer *et al.*[3] for different

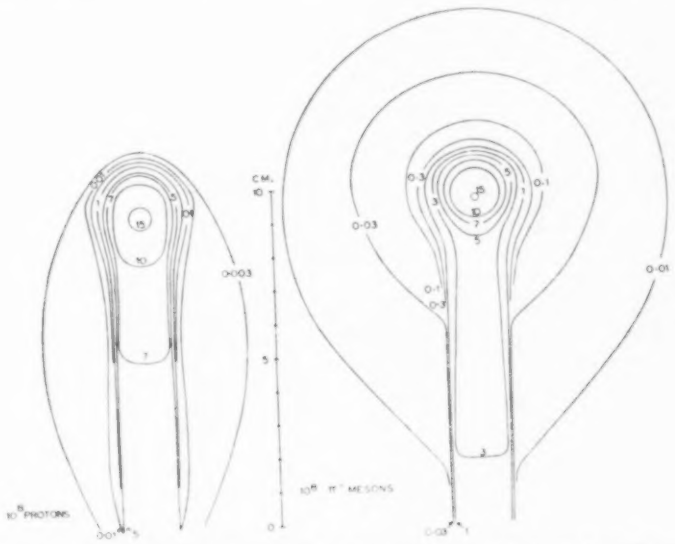


Fig. 3. Calculated radiation fields due to initially parallel beams of protons and negative pions traversing biological tissue. At entry, each beam is of uniform density over a circular cross-section of radius 0·84 cm. The mean momentum was chosen to give a range of 10 cm. in body tissue. The spread of momentum of each beam was taken to be rectangular in form and of total width given by $\Delta p/p = 4{\cdot}5$ per cent; so that the most concentrated radiation damage occurs in a volume of roughly cylindrical form, of length equal to its diameter, centred at the end of the range (10 cm.)

In calculating the radiation intensity, allowance has been made for lateral Coulomb scattering of the beams and straggling in range. The total dose is made up of the effects of ionization loss due to (i) the incident beam and (ii) charged and neutral secondary particles from nuclear interactions of the protons in flight, and of the pions in flight and at rest. The numbers alongside the contours refer to the dose in rads for 10^8 incident pions, or protons

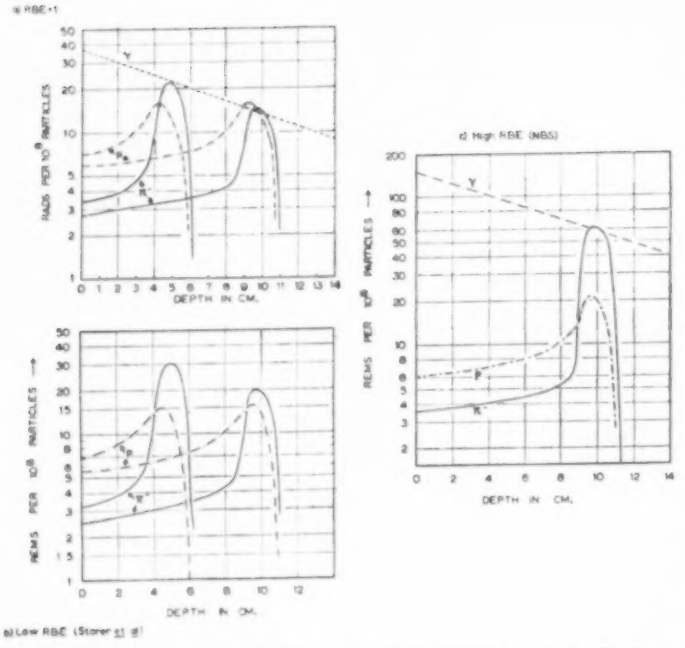


Fig. 4. (*a*) Axial radiation fields corresponding to the contours of Fig. 2. The (unnormalized) field due to a cobalt-60 γ-ray beam is also indicated
(*b*) and (*c*) Axial radiation fields of proton and pion beams of ranges 5 cm. and 10 cm. respectively, where the values for the relative biological effect of Storer *et al.* and the National Bureau of Standards recommendations are employed

particles producing lethal and other effects in rats and mice. For a variety of heavily ionizing particles, they obtain values of relative biological efficiency in the region 1·5–3·0. In view of these uncertainties, we have computed the distribution of radiation damage in rems (1 rem = 1 rad × relative biological efficiency) due to beams of negative pions, using in turn values of relative biological efficiency of unity for all particles, those of Storer *et al.*, and those recommended by the National Bureau of Standards. It seems probable that values appropriate to the present problem will lie between these extremes.

Fig. 4*a* represents the axial radiation dosage taken from the contours of Figs. 2 and 3. These fields correspond therefore to the use of a value of unity for relative biological efficiency. Fig. 4*b* shows the axial dose for π-mesons and protons assuming the values of Storer *et al.*[2], and Fig. 4*c*, that for the high values recommended by the National Bureau of Standards[1]. Calculations were made for ranges of both 5 cm. and 10 cm. The effect on the peak intensity of the lateral dispersion of the beam due to Coulomb scattering is very small for pions of 5-cm. range, and for protons of either range; but it reduces the peak intensity for pions of 10-cm. range by a factor of ~1·5.

The important feature illustrated by these results is that, whichever set of values for relative biological efficiency is taken, the dose received in a spherical volume centred near the end-point of the pion beams, and called here the 'tumour region', is much greater than that delivered in any of the surrounding tissue. The greatest dose outside the tumour region is of course in the path of the incoming beam, but the dose gradient even in this direction is very large.

The degree of concentration of the radiation damage in the region of the end-point is also illustrated in Table 1. These figures show the superiority of the pion irradiations over those by protons or γ-rays. The 'figures of merit' for the various beams have been specified in two ways: either by the ratio of the total dose delivered to the tumour to that in the whole of the surrounding tissue; or by the ratio of the dose per unit volume at the centre of the tumour to the maximum dose per c.c. delivered in a nearby region. For this purpose, we show the dose at the centre of irradiation divided by the maximum dose 1·5 cm. away from it.

The results show that, for single parallel beams of γ-rays and fast protons (and indeed neutrons), the radiation damage per unit volume in the tumour is no greater than that in the surrounding tissue, and that only a small fraction (less than 10 per cent) of the total body damage is confined to the tumour. Both these features are highly undesirable. In contrast, for a beam of π⁻-mesons, the damage per unit volume is many times greater in the tumour than in adjoining regions, and the total damage in the tumour region appreciably exceeds that in the whole of the surrounding body tissue. In principle, therefore, the advantages of a beam of π⁻-mesons appear to be very great.

The preceding results refer to irradiations over a tumour volume with linear dimensions of about 2 cm.; the lateral extent of the incoming beam, and the spread of momentum in the beams were so chosen as to irradiate such a volume nearly uniformly. If it were desired to treat a smaller volume, the characteristics of the beam could be altered accordingly.

In Fig. 5 we show the axial radiation field for pion and proton irradiations, with the fractional momentum spread of the beam, and its lateral extent, each reduced by a factor 2. This would correspond to irradiation of a tumour of one-eighth of the previous volume. The superiority of the π⁻-meson irradiation over the proton or γ-ray irradiation is apparent, and is somewhat more marked than when larger volumes are irradiated. The minimum volume within which one can restrict an appreciable fraction of the radiation damage is determined, for stopping particles, by the lateral spread produced by Coulomb scattering. As shown in the Appendix, this spread is nearly proportional to the depth of penetration (that is, the beam range).

Table 1

Radiation	(Tumour)/(External damage)		(Dose at tumour centre) / (Max. dose 1·5 cm. away)	
	Tumour depth		5 cm.	10 cm.
Cobalt-60 γ-rays	0·11	0·07	0·9	0·9
Fast protons	0·08	0·08	1·0	1·0
Ending protons	0·9–1·3	0·4–0·6	1·4–1·9	1·4–1·9
π⁻-mesons	1·7–3·8	0·9–1·9	4·4–13	3·4–10

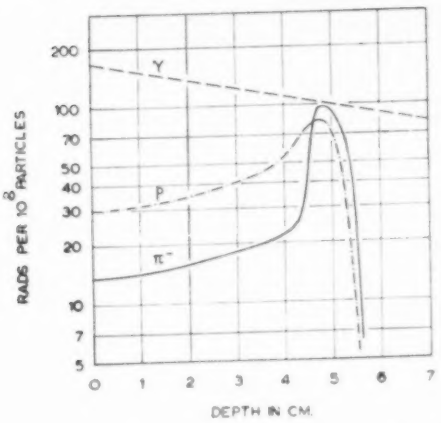


Fig. 5. Axial radiation field for the case of beams of radius 4 mm. and spread of momentum such that the particles end over a band of range 8 mm. in extent at a mean depth of 5 cm. Relative biological efficiency taken as unity for all particles

When employing γ-rays it is normal practice, in order to reduce the dose to healthy tissue adjacent to the tumour, to irradiate from several directions. The same advantage can be gained in the case of beams of low-energy protons or π^--mesons; for the latter, it may also prove practicable to produce a converging beam in a single exposure, because the momentum of the pions of the required range is quite low ($\approx$ 100 MeV./c.).

In view of these apparently great advantages, it appeared worth while to examine whether, with accelerators and their associated equipment at present available, which have been designed for the quite different purpose of making refined experiments with beams of fast elementary particles, it would be possible to secure irradiations of sufficient intensity in a reasonable time. For this purpose, on the basis of the results summarized in the figures, we estimate that a treatment of a tumour with an irradiation of 400 rems would require the arrest of up to 10^9 π^--mesons per c.c., or an incident beam of up to 5×10^8 pions/cm.^{2}, with a total spread of momentum of 4-5 per cent.

The Liverpool cyclotron, working with protons of energy 400 MeV. bombarding a thin beryllium target, can produce an analysed beam of π^--mesons of energy 90 MeV., and with a total spread of momentum of 4 per cent. The number of π^--mesons in the beam is $\sim 10^8$/cm.^{2}/sec. This beam is produced with a single quadrupole (focusing) magnet followed by a deflecting magnet for analysis of momentum. It is believed that a second stage of focusing would allow a large fraction of the original beam to be focused into a spot a few square centimetres in area. With the existing beam, the time of exposure required would therefore be up to 10^6 sec.

Doubtless improvements of intensity in a specially equipped machine could be secured by a suitable choice of the target element, by increasing the mean proton current and by employing focusing magnets of higher aperture, which would appear feasible for the low-momentum beams required. It seems likely also that the pion yield in the region of 50 MeV. could be made considerably bigger by a moderate increase in proton energy. In view of these factors, it appears not unreasonable to suggest that beams of π-mesons 1,000 times more intense than those at present available in Liverpool would be technically feasible without any radical changes in present equipment, and that the shielding problem could be overcome. The corresponding exposure times for 10^4 particles would then be 1,000 sec.

These considerations make it desirable to determine in more detail the physical processes involved; and to make measurements of the actual distributions of the points of arrest of π-mesons injected into biological tissue; on the distribution of the ionization due to both charged and neutral particles from the arrested π-mesons; and of a number of other quantities. Such experiments are at present being designed and will be carried out in the near future. It will also be necessary to consider the question of the most advantageous forms of shielding from the high neutron fluxes generated at the target.

We may remark that our calculations indicate the marked superiority of beams of protons over γ-rays for therapeutic purposes. Although beams of protons are markedly inferior to pions, their production in sufficient intensity would be possible with technical methods already established, and they would have great advantages over γ-rays from cobalt-60.

Table 1 shows the ratio of the radiation dose delivered to a tumour compared with that in adjacent regions. The tumour is taken to be of radius 1·5 cm., and to be situated at a depth of 5 cm. or 10 cm. from the skin. In columns 2 and 3 the total external dose refers to that in a sphere of radius 10 cm. Calculations have been made for initially parallel beams of optimum width; and, for the low-energy protons and pions, with the optimum band of momentum. For columns 3 and 4 the figures apply to a single irradiation only. If irradiation is made from different directions, the values will increase by a factor which is practically the same for all four types of radiation.

The pair of figures given for the beams of slow protons and π^--mesons refer to a value of unity for the relative biological effect, and the high value recommended by the National Bureau of Standards, respectively. The fast-proton beam is assumed to be of sufficient energy to pass through the entire volume with only a small change in velocity.

Appendix

(*a*) *Lateral spread of a beam due to Coulomb scattering.* Consider a parallel pencil beam of initial energy E_0 and initial range R_0. Let $\overline{\alpha^2}$ be the mean square angle of multiple scattering of the particles in the beam per unit path-length when they possess residual range R. The total mean square lateral deviation of the points of arrest, $D_\perp^2$, is then given by:

$$D_\perp^2 = \int_0^{R_0} \overline{\alpha^2} R^2 \mathrm{d}R$$

$\overline{\alpha^2}$ for tissue is given by:

$$\overline{\alpha^2} = 10{\cdot}6/(p\beta)^2 \text{ (radians)}^2\text{/cm.}$$

where p is the momentum measured in MeV./c. and βc is the velocity of the particles at any point along their trajectory.

For the ranges R under consideration, $p\beta$ is given to sufficient accuracy for π-mesons by the relation:

$$p\beta = 24R^{0{\cdot}58} \text{ MeV./c.,}$$

where R is measured in cm.

Hence

$$\overline{D_\perp^2} = 1{\cdot}84 \times 10^{-3} \int_0^{R_0} R^{0{\cdot}84} dR = 1{\cdot}0 \times 10^{-2} R_0^{1{\cdot}84} \text{ cm.}^2$$

The root-mean-square projected value of $D_\perp$ along any direction perpendicular to the initial beam is $D_\perp/\sqrt{2}$ and is thus

$$D_{\perp \text{ proj.}} = 7 \times 10^{-2} R_0^{0{\cdot}92} \text{ cm.}$$

Thus for 52-MeV. π-mesons, for which $R_0 = 10$ cm., $D_{\perp \text{ proj.}} = 0{\cdot}6$ cm. For other values of R_0, the ratio $(D_{\perp \text{ proj.}})/R_0$ remains almost constant. The lateral distribution of density of the points of arrest of the π-mesons at a distance D perpendicular to the beam is given by a Gaussian distribution :

$$I = I_0 \exp - \frac{D^2}{2(D_{\perp \text{ proj.}})^2}$$
$$= I_0 \exp [-1{\cdot}4D^2], \text{ for } R_0 = 10 \text{ cm.}$$
$$= I_0 \exp [-5D^2], \text{ for } R_0 = 5 \text{ cm.}$$

At any intermediate point between entry and the point of arrest where the residual range is R cm., the root-mean-square lateral deviation $D_{\perp \text{ proj.}}(R)$ is given by :

$$D_{\perp \text{ proj.}}(R) = D_{\perp \text{ proj.}} \left[14{\cdot}9 \left(\frac{R}{R_0}\right)^{1{\cdot}84} - 11{\cdot}5 \left(\frac{R}{R_0}\right)^2 - 4{\cdot}4 \frac{R}{R_0} + 1 \right]^{1/2} \text{ cm.}$$

which may be approximated by :

$$D_{\perp \text{ proj.}}(R) = D_{\perp \text{ proj.}}[1 - R/R_0]^2 \text{ cm.}, \qquad R < R_0/2$$
$$= \frac{D_{\perp \text{ proj.}}}{\sqrt{2}} [1 - R/R_0]^{2/3} \text{ cm.}, \qquad R > R_0/2$$

(*b*) *Longitudinal spread (straggling) of homogeneous beam.* The projections of the end-points of the pion tracks along the axis of the pencil are also spread out, due to statistical fluctuations in the energy loss. This distribution is again practically Gaussian. The root-mean-square value of this straggling about the mean range R_0 cm. in body tissue is :

$$D_{\parallel \text{RMS}} = 2{\cdot}6 \times 10^{-2} R_0^{0{\cdot}94} \text{ cm.}$$

or $D_\parallel/R \sim 2{\cdot}3$ per cent for values of R_0 between 5 and 10 cm.

This figure for the straggling in range of a homogeneous beam of π^--mesons is probably smaller than one would require. So the longitudinal spread will be determined in practice by the spread in energy of the incoming π^--mesons ; this can be adjusted by the movement of slits in the magnetic focusing system that would be employed. To obtain a spread of $\pm$ 5 mm. at 10 cm., an energy spread of $\pm$ 3 per cent in the incoming beam would be required. Such resolution is readily obtained.

We wish to thank Prof. C. F. Powell for his great interest and encouragement, and for discussions. We are also indebted to Mr. H. F. Freundlich for several discussions, and for Fig. 2 of this article. After preparing this report, we were informed by Dr. R. D. Hill, of the University of Illinois, that he had considered the problem previously (1958) and had circulated his conclusions in a private letter to certain medical authorities in the United States. These conclusions were somewhat different from those presented here, and the advantages of pion beams over existing beams of protons and γ-rays were not considered sufficiently substantial to warrant further pursuit of the matter.

[1] National Committee on Radiation Protection, Handbook 59, p. 48 (National Bureau of Standards, 1954).
[2] Snyder, W. S., and Neufeld, J., *Radiation Res.*, **6**, 67 (1957).
[3] Storer, J. B., Harris, P. S., Furchner, J. E., and Langham, W. H., *Radiation Res.*, **6**, 188 (1957).

THE PERCEPTION OF SPEECH

THE growth of communication in the modern world has added a new dimension to applied psychology. In the air traffic control tower, the police information room, or the telephone switchboard of a large concern, men are daily subjected to a barrage of spoken messages with which they are expected to deal speedily and efficiently. In some of these situations, at least, human error can prove disastrous. It is therefore of obvious importance to ascertain the extent to which the human operator can handle a plurality of speech messages, and the factors which dispose him to error. What, in short, are the limits of the human operator conceived as a receiver and transmitter of spoken information ?

This question was the theme of a Friday evening Discourse at the Royal Institution on November 18, delivered by Mr. D. E. Broadbent, director of the Medical Research Council's Applied Psychology Research Unit at Cambridge. Although taking the predicament of the air traffic controller as his point of departure, Mr. Broadbent was clearly more concerned with the theoretical upshot of recent work than with its contribution to immediate ends. He directed particular attention to the perception of simultaneous, or nearly simultaneous, messages, to which much research has been devoted during the past ten years. It is now clear that the familiar difficulty in 'hearing two things at once' cannot be ascribed primarily to masking or related interference at the physiological level, and seems due rather to difficulty in allocating the individual words heard to their respective contexts, that is, to perceptual confusion[1]. This difficulty, as Mr. Broadbent pointed out, may be appreciably reduced if the two messages differ in salient characteristics ; for example, if spoken in different voices or appearing to originate from different points in space[2]. Indeed, spatial separation has been shown to be particularly effective in reducing error, more especially under conditions in which some of the information is irrelevant to the purposes of the listener[3]. Effective, too, is probability of message in the sense of the communications engineer. The extent to which different messages can be handled at the same time appears to depend not so much on the number of words reaching the two ears as upon the probability of each message. Indeed, two highly probable signals may in fact be perceived simul-

Appearing in February

Regional Neurochemistry

THE REGIONAL CHEMISTRY, PHYSIOLOGY AND PHARMACOLOGY OF THE NERVOUS SYSTEM

Edited by SEYMOUR S. KETY and JOEL ELKES

Contains the authoritative proceedings of the Fourth International Neurochemical Symposium, Varenna. Among the papers delivered were, Regional Distribution of Methyl Transferase Enzymes in the Nervous System and Glandular Tissues by J. Axelrod, P. D. Maclean, R. Wayne Albers and H. Weissbach, and a distinguished list of participants discussed such topics as Copper Distribution in the Human Brain and the Effects of Drugs on Neurons.

84s. net ($12.00)

The Biology of Stentor

A STUDY OF INTRACELLULAR ORGANIZATION

VANCE TARTAR, *University of Washington, Seattle*

Summarizes and correlates all that is known about a certain group of unicellular organisms, ciliate protozoa of the genus stentor, which are amenable to more extensive micrurgical operations than any other type of cell and are eminently suitable for classroom study.

75s. net ($12.00)

Control of Ovulation

Edited by CLAUDE A. VILLEE, *Harvard Medical School, Boston*

Contains the proceedings of a conference sponsored by Harvard University and the Association for the Aid of Crippled Children, New York City, to review and evaluate the experimental evidence upon which the current concepts of the mechanisms controlling ovulation are based.

70s. net ($10.00)

Soviet Refrigeration Technology

A BIBLIOGRAPIC HANDBOOK

D. N. PRILUTSKII

In this invaluable bibliographical reference book are published results of research work and of practical experiment that have appeared in the proceedings of all the major Russian Refrigeration Research, Training, and Project Designing Institutes, and other organizations engaged in scientific investigations in the field of refrigeration.

63s. net ($10.00)

An Introduction to Co-ordination Chemistry

D. P. GRADDON, *Senior Lecturer in Inorganic Chemistry, University of New South Wales*

A valuable introduction to the subject at university level concerned almost entirely with recent advances but beginning with a historical résumé for proper perspective.

25s. net ($4.00)

Please send for fully descriptive leaflets

PERGAMON PRESS

OXFORD LONDON NEW YORK [PARIS

Headington Hill Hall, Oxford.
4 & 5 Fitzroy Square, London W.1.
122 East 55th Street, New York 22, N.Y.

AUTOMATIC POLISHING MACHINE

for metallurgical specimens

New design with novel features essential for the modern works laboratory

Please write for details

R. & J. BECK LTD.

69/71 Mortimer St. London W.1

A MAGNIFIER OF THE HIGHEST QUALITY

The beautifully made, well finished magnifier illustrated above has a triple cemented fully corrected lens giving a flat field completely colour-free. It gives a magnification of ×20 linear. The metal parts are well made, designed, finished and chrome plated. The screws have locking washers.

- *Magnifier No. 1067 ×20.*
- *Also made in ×8 and ×10 magnification with larger aperture.*
- *List No. 163 illustrates and describes all the range of magnifiers.*

Manufactured by:

GOWLLANDS LTD

MORLAND ROAD, CROYDON, SURREY

Obtainable from all scientific instrument suppliers.

Contributed by ELGA PRODUCTS LIMITED

Water Purification by deionisation is now widely accepted as an invaluable technique for laboratories and many industrial applications. Other applications of ion exchange are, perhaps, not so well known, and one is now briefly described.

Removal of Metal Ion Contaminants

Ion Exchange resins may be employed to effect complete and rapid removal from solution metal ions which, because of their taste, colour, smell, or toxicity, are undesirable in many processes or products. A cation resin is used, and one example is the removal of iron from phosphoric acid pickling baths. Industries using this technique include Food Processors, Pharmaceutical Manufacturers, Textile Mills, Chemical Manufacturers, Dye Works, Tanneries and Paper Mills.

Recovery of Metallic Ions

Valuable metals in ageous solutions can be adsorbed on a suitable Cation resin, which is subsequently treated to recover the adsorbed metal. Typical examples of metals which may be salvaged or concentrated in this way are :

Copper—from rayon and pickling wastes
Gold—from industrial wastes
Chromium—from plating baths
Rare Earth Metals—from their ores
Isotopes (concentrated)
Magnesium—from sea water.

Part of this information has been condensed from Rohm & Haas Publication IE-3-53a.
In following issues it is hoped to deal with further specific applications.

Elgastat Deionisers are contributing to Research throughout the world by providing ultra-pure water at a turn of a tap.

By Appointment to Research

ELGA PRODUCTS LIMITED · LANE END · BUCKINGHAMSHIRE Tel.: LANE END 396

PG272/D

taneously. In general, Mr. Broadbent is on strong ground in advocating the view that the human brain, in virtue perhaps of its limited size, possesses a limited capacity for the processing of information.

A closely related problem is dichotic listening, that is, the perception of speech fed by independent channels to the two ears. Some years ago, Prof. Colin Cherry was able to show that the effects of feeding two different messages simultaneously, one to each ear, are entirely different from those that are obtained if the same messages are 'mixed' on a tape recording and the two ears stimulated identically[4]. In the case of the independent messages, the observer has no difficulty in listening to one or other message at will or in repeating it concurrently. He can, however, repeat virtually nothing of the 'rejected' message beyond perhaps the sex of the speaker. Yet this 'rejection' is not quite absolute: individual words arriving at the 'rejected' ear may sometimes be heard; for example, the listener's own name[5] or a word fitting more appropriately into the context of the message to which attention is being paid than that actually arriving at the 'accepted' ear[6]. There is evidence, moreover, of short-term 'storage' of the 'rejected' information. In earlier experiments, Mr. Broadbent demonstrated that if a short series of digit pairs was given dichotically, these digits could be correctly recalled, though not in their order of arrival. Almost invariably, the subject repeated first the digits fed to one ear and then those fed to the other[7]. More recent work has, however, suggested that this kind of selection is not governed exclusively by the ear to which attention is given. For example, if three monosyllabic words forming a short sentence are fed simultaneously with three digits such that words and digits alternate at the two ears, subjects are found to repeat first the sentence and then the number, or *vice versa*[8]. It seems possible, then, to listen for words as opposed to numbers just as one can listen to one ear as opposed to the other. At the same time, the existence of obvious differences between these two kinds of selection might suggest that they are governed by different types of cerebral mechanism.

Although few of the phenomena of speech perception find ready explanation in neurological terms, Mr. Broadbent argued in his discourse that the issues which they raise have an important bearing on auditory theory. For example, a vowel sound contains several different components at widely different frequencies, and to identify it requires that one should pick out the several components and treat them as pertaining to the same voice rather than the background noise. How does the auditory mechanism effect this discrimination? Although no very complete answer can be given, Mr. Broadbent suggested that amplitude modulation may play an important part. If a tuned system is subjected to amplitude modulation, the pitch of the resulting sound will, in appropriate conditions, correspond not to that of a steady wave having the frequency of the system but to that of the imposed pulses. In the case of the ear, one may argue that the pitch of a sound will depend not so much on the precise receptors stimulated (as traditional theory holds) as on some feature of the message travelling up the nerve fibres and affected by the rate of amplitude modulation. A likely candidate, Mr. Broadbent suggests, is the frequency of impulses in the auditory nerve. Although no direct neurophysiological evidence is available, Mr. Broadbent argues that experiments with 'synthetic speech' in which different parts of the spectrum can be modulated at different rates are well adapted to test this theory.

The study of speech perception and related problems is advancing with encouraging rapidity. Although the point of view of the applied psychologist influenced by communications theory is not always easy to reconcile with that of the sensory physiologist, the approach outlined by Mr. Broadbent has certainly served to throw valuable light on the limits of the auditory mechanism and on the selective processes which operate in the perception of speech. It may be hoped that the next step will be the translation of the models derived from information theory—which Mr. Broadbent has himself done much to develop—into those of neurophysiology. This possibility one recent writer at least regards as a great deal less remote than is commonly supposed[9].

[1] Broadbent, D. E., *Perception and Communication* (Pergamon Press, London, 1958).
[2] Hirsh, I. J., *J. Acoust. Soc. Amer.*, **22**, 196 (1950).
[3] Poulton, E. C., *J. Exp. Psychol.*, **46**, 91 (1953).
[4] Cherry, E. C., *J. Acoust. Soc. Amer.*, **25**, 975 (1953).
[5] Moray, N., *Quart. J. Exp. Psychol.*, **11**, 56 (1959).
[6] Moray, N., and Taylor, A., *Language and Speech*, **1**, 102 (1958).
[7] Broadbent, D. E., *J. Exp. Psychol.*, **47**, 191 (1954).
[8] Gray, J. A., and Wedderburn, A. A. I., *Quart. J. Exp. Psychol.*, **12**, 180 (1960).
[9] Gerard, R. W., *Handbook of Physiology: 1. Neurophysiology*, **3**, 1919 (Amer. Physiol. Soc., 1960).

OBITUARY

Prof. H. T. S. Britton

Prof. Hubert Thomas Stanley Britton died after a short illness on December 30; he is survived by his son and daughter. Born at Kingswood on April 22, 1892, he was educated in Bristol at St. George's Grammar School, the Merchant Venturers' College and the University of Bristol, graduating thence in 1914. He spent a short period as a grammar school master and then served during 1916–20 as chemist in the Aeronautics Inspection Department, and during 1920–25 as assistant lecturer at King's College, London. Between 1925 and 1927 he held a senior award of the Department of Scientific and Industrial Research at the Imperial College of Science and Technology, London, and then, after a year or so as lecturer at Norwood Technical College, he commenced his long association with the then University College of Exeter, first as lecturer and then, from 1935 until his retirement, as professor.

Despite a very heavy load of teaching—in the early years he was responsible for the whole of the honours teaching in physical and inorganic chemistry—Prof. Britton was extremely active in research, publishing numerous papers and directing the work of a considerable number of research students. Beyond the confines of his Department he was a prominent figure on the Senate, served at some time on the councils of the Chemical Society, the Royal

Institute of Chemistry and the Society of Chemical Industry, was for a period chairman of the board of governors of the North Devon Technical College, and was a popular extra-mural lecturer. He was instrumental in securing the establishment of the local sections of the Royal Institute of Chemistry and of the Society of Chemical Industry, and played a leading part in the preparations for the elevation of the College to university status.

Britton's research interests lay in the physico-chemical investigation of inorganic reactions in solution, mainly by measurements of the potentials of electrolytic cells incorporating hydrogen, glass and metal electrodes, but also including electrical conductance, diffusion and dialysis, phase-rule studies and polarimetry. He accumulated a mass of quantitative data relating to the precipitation of hydroxides, hydrated oxides and basic salts of numerous metals, and to the formation of complex ions involving a variety of acids and bases; he made notable contributions to the 'solution' chemistry of less-common elements such as vanadium, molybdenum and ruthenium, and with Robinson devised the well-known 'universal buffer mixture' which bears their names. Britton's *Hydrogen Ions*, which ran to four editions, is an indispensable reference book in every laboratory concerned with the physico-chemical behaviour of solutions of electrolytes.

Britton was the most approachable of men, ever warm-hearted and friendly, and was extremely popular with his students. He was a lively and entertaining lecturer whether to undergraduates or to an extra-mural audience in the heart of rural Devon, and he retained to the end something of the sceptic and the rebel. As head of department, he made himself freely accessible at all times to staff and students alike, and to colleagues from other departments. On his retirement in 1957 he was made emeritus professor, but his life in retirement was clouded by anxiety over his wife's failing health, and, in June 1959, her death.

Britton will live long in the affectionate memories of the many students who passed through his hands. His writings and researches contributed much to the chemistry of ionic solutions, and he laid the secure foundations on which the future development and expansion of the Chemistry Department at Exeter may confidently be based. S. J. Gregg

NEWS and VIEWS

The Space Vehicle 1961γ

A heavy Earth satellite was projected into orbit from a launching point in the U.S.S.R., probably at a time near midnight on February 11–12, and early on February 12 a space vehicle was launched from the heavy satellite, with the aid of a rocket which accelerated it to a speed greater than the escape speed of 11 km./sec. This space vehicle, which weighs 643·5 kgm. (1,419 lb.), was directed along a flight path designed to take it into the vicinity of the planet Venus, which it is expected to reach in the second half of May 1961, when the planet will be about 70 million km. from the Earth. At 9 hr. U.T. on February 12, the space vehicle was stated to be 126,300 km. from the Earth's surface at longitude 86° 40′ E. and latitude 6° 04′ N.; 24 hr. later, the distance had increased to 489,000 km., at longitude 88° 2′ E. and latitude 0° 53′ N. The vehicle's radio transmitter operates, on command, at a frequency of 922·8 Mc./s., and is to be switched on every 5 days. It is powered by chemical batteries, and these are re-charged by solar cells, which are orientated towards the Sun. The main purposes of the vehicle are to test the procedures for launching bodies into interplanetary orbits, to test guidance systems and communication at extreme distances, to investigate the size of the solar system, and to measure various physical properties of interplanetary space.

This vehicle, by far the heaviest yet launched into interplanetary space, represents a substantial step forward in space technology. Its flight was preceded by the launching of the heaviest Earth satellite, 1961β, weighing 6,483 kgm., which was put into a close orbit on February 4, and apparently served as a test vehicle for 1961γ. Any physical measurements made by the space vehicle in the neighbourhood of Venus will add to our scanty knowledge of this inscrutable planet; but it has not been disclosed whether the vehicle carries the terminal guidance which would be needed to make a very close approach to the planet.

The Science Museum Library: Mr. J. A. Chaldecott

Mr. J. A. Chaldecott has been appointed keeper of the Science Museum Library in succession to the late Mr. H. T. Pledge. Mr. Chaldecott, who has been secretary to the Advisory Council of the Science Museum and deputy keeper in the Department of Physics since February 1957, was educated at Latymer Upper School, Hammersmith, and at Brentwood School. He read physics and mathematics at Borough Road College, graduating at the University of London in 1938. Early the following year he was commissioned in the Meteorological Branch of the Royal Air Force Voluntary Reserve; for much of the Second World War he was seconded to army formations, and his services earned him mention in dispatches. After the War he read history and philosophy of science at University College, London, obtaining his M.Sc. in 1949. He was lecturer in physics at Acton Technical College for a short period before entering the Science Museum, in 1949, as an assistant keeper. He catalogued the George III collection of scientific instruments, the heat and thermal instruments collection, and also edited the commemorative volume *The Science Museum: the First Hundred Years*. His published papers have been in the history of physics. He is a member of Council of the British Society for the History of Science.

Ministry of Aviation: Mr. F. H. Scrimshaw

Mr. F. H. Scrimshaw has been promoted to the rank of deputy chief scientific officer. In 1939 Mr. Scrimshaw graduated in physics at the University of London with honours and was awarded the Granville research studentship as the best University of London

physics graduate of the year. His first work at the Royal Aircraft Establishment, which he joined in 1939, was concerned with bomb-sights, followed by a spell during 1942–45 of research on airborne automatic dead-reckoning navigation equipment. On the formation of the Blind Landing Experimental Unit at Martlesham in 1945, Mr. Scrimshaw took charge of the flight control section which investigated such problems as the use of automatic pilots, leader cable guidance and automatic throttle control to aircraft landings. This work has come to fruition recently in the British Auto-land system which Britain is now actively sponsoring for use by civil airlines. In 1950 Mr. Scrimshaw returned to the Royal Aircraft Establishment, where he continued to work on inertia navigation systems, becoming an acknowledged expert in this field. He continued this work until 1958, when he became director of scientific research (electronics) at headquarters of the Ministry of Aviation. In this post Mr. Scrimshaw has been associated with long-term research projects in electronics in which the Ministry of Aviation has been engaged.

Anatomy at Cardiff : Prof. J. D. Lever

Dr. Jeffrey D. Lever has been appointed, in succession to the late Prof. J. S. Baxter, to the chair of anatomy in the University College of South Wales and Monmouthshire, Cardiff. Dr. Lever was educated at Westminster School and at Trinity College, Cambridge, which he joined as an Exhibitioner in 1941. He graduated in medicine in 1946, having pursued his clinical studies in St. Thomas's Hospital. After service in the Navy he joined the academic staff of the Anatomy Department in Cambridge as a University demonstrator. He was awarded the M.D. degree in 1954, and, in 1955, was appointed to a lectureship. During the academic year 1954–55 he was visiting instructor and research assistant in the Department of Anatomy, Washington University, St. Louis, where, under the direction of Dr. E. W. Dempsey, he received a training in electron microscopy. His interests as a research worker are concerned largely with the functional histology and fine structure of the endocrine glands. His publications include contributions on the adrenal gland, the islets of Langerhans, the parathyroids, and the carotid body. In 1956, on the recommendation of the Anatomical Society, he was awarded the Symington Prize, for original work in anatomy, by the Senate of The Queen's University of Belfast. He was elected to a fellowship of Trinity College, Cambridge, in 1957, and since then has been director of medical studies in the College. He is a member of the Council of the Anatomical Society.

A Co-operative Space Research Programme

Replying to a request in the House of Commons for a statement on progress achieved towards a Commonwealth and European space research programme, the Minister of Aviation, Mr. Peter Thorneycroft, said that at the Strasbourg Conference delegates had expressed keen interest in the political, scientific, economic and technological advantages of co-operation in the manufacture of launchers for heavy satellites. If an organization for this purpose was set up, it would be on a long-term basis, and could as its first programme use the British *Blue Streak* as a first stage, a French rocket as a second stage, and a third stage manufactured elsewhere in Europe. The United Kingdom and French Governments would now be asking their partners in the Conference to study its results with the view of deciding whether to form such an organization. The Federal Republic of West Germany was in principle to take part, but had neither the possibility of, nor the interest in, developing a rocket of its own for space purposes. As to co-operation with other countries, Mr. Thorneycroft said that Australia would undoubtedly be the place from which this programme, using *Blue Streak* as a first stage, would be launched, and we would, of course, welcome every co-operation with the United States. The British subscription would be on the basis of 33¼ per cent which, on the estimated cost of £70 million, would be £23,300,000 over five years.

The Cotton, Silk and Man-made Fibres Research Association

In a written answer in the House of Commons on February 9, the Minister of Education, Sir David Eccles, as representing the Minister for Science, stated that it is proposed that the merger of the British Cotton Industry Research Association and the British Rayon Research Association into one association, to be called the Cotton, Silk and Man-made Fibres Research Association, will be effective from April 1, 1961. The annual expenditure will rise from about £490,000 to about £580,000 over the next five years, the industrial income being sought mainly from processers of cotton and man-made fibres by statutory levy under the Industrial Organization and Development Act, together with support from producers of man-made fibres. The new Research Association would occupy the present site of the Cotton Research Association at Didsbury, where the laboratories will be extended, and the laboratories of the Rayon Research Association at Heald Green will be sold. The research staff of the new Association will be drawn from the existing Associations, with adequate provision for redundancy, including retirement pensions, compensation and placing staff in other employment.

Committee on Higher Education in Britain

The Prime Minister announced, on December 20, that Lord Robbins would be chairman of the committee to consider higher education in Britain, and the terms of reference of the committee were announced (see *Nature*, February 11, p. 427).

The members of the committee have now been announced. They are : Sir David Anderson, formerly director of the Royal College of Science and Technology, Glasgow ; Dame Kitty Anderson, headmistress, North London Collegiate School ; Mr. A. Chenevix-Trench, headmaster, Bradfield College, Berkshire ; Prof. J. M. Drever, professor of psychology and lately dean of the Faculty of Arts, Edinburgh ; Mr. A. L. Elvin, director of the University of London Institute of Education ; Miss Helen Gardner, professorial fellow, St. Hilda's College, Oxford ; Sir Edward Herbert, an engineer, chairman of the governing body of Loughborough College of Technology and member of the Court of the University of Nottingham ; Sir Patrick Linstead, rector of the Imperial College of Science and Technology, London ; Sir Philip Morris, vice-chancellor of the University of Bristol ; Mr. H. C. Shearman, vice-president of the Workers' Educational Association ; Mr. R. B. Southall, general manager of the Llandarcy (BP) refinery, Swansea.

Research Expenditure on Fisheries

The report of the committee of inquiry into the fishing industry, of which Lord Fleck was chairman, laid emphasis on adequate finance being available for scientific and industrial research bearing on the industry. In moving the second reading of the White Fish and Herring Industries Bill in the House of Commons on January 31, the Minister of Agriculture, Fisheries and Food, Mr. C. Soames, said that the Bill was not prompted by the Fleck report, to implement which would require major legislation and detailed consultation before such legislation could be drafted; and the importance of research for the fishing industry was stressed. Mr. J. H. Hoy suggested that if the normal fishing grounds were contracted, research directed towards the discovery of new fishing grounds should be undertaken; and Capt. M. Hewitson inquired specifically whether the possibility of fishing grounds off the coast of Ghana had been investigated. He thought the prospects of industrial fishing in that area were unlimited. Sir William Duthie also strongly urged adequate research to remove as much guesswork as possible from fishing, particularly as regards the incidence of shoal migration, and suggested that in this way we could find the answer to the depletion of the herring shoals in the North Sea. Other speakers agreed that, as the Fleck Committee pointed out, the fishing industry in many aspects lags behind other industries in the adoption of modern equipment, methods and organization; but it is also recognized that the question of research is closely linked with the economic aspects, since the application of its results increasingly involved large capital expenditure, beyond the resources of the small owner.

Mr. H. Hughes, who quoted the estimated figure of £1 million for expenditure by Britain on fisheries research in 1959–60, with a further £250,000 for research into handling and processing fish, referred also to the view of the Fleck Committee that a much more intensive research effort could profitably be directed towards exploiting more effectively the resources of the sea, and that to keep pace with changing conditions, the industry should devote a substantially greater sum to the development of improved catching and processing techniques. Questions raised in the debate relating to the closing of one of the three research stations at Aberdeen led the Secretary of State for Scotland, Mr. J. S. Maclay, to be at some pains to explain that the station which had been sold to Unilever, Ltd., which would continue research there, was the Ministry of Agriculture, Fisheries and Food Experimental Food Station, which was not primarily a fishing research station. The Marine Life Laboratory of the Department of Agriculture and Fisheries for Scotland, adjacent to the Department of Scientific and Industrial Research's research station at Torry, are both continuing and cover research into fish and the sea, biology, hydrography and the abundance and distribution of commercial fish stocks.

Telephone Services in Britain

In opening a debate in the House of Lords on February 11 on the Post Office Telephone Service, prompted by the White Paper (Cmnd. 973) on *Post Office Capital Expenditure*, 1960–61, Lord Crook said that there are at least six main reasons why a steady figure for capital investment is essential for the telephone service. One of these is a steady research programme, and this is closely related both to the telecommunications industry and to the growth of electronics in the world of the telephone, where, Lord Crook believes, Britain is in danger of losing a great market. He questioned whether the Dollis Hill Experimental Establishment has been allowed to get ahead fast enough and given sufficient opportunity and finance. It is important, he said, to realize that the telephone service earns money, internally in industry within Britain, and also in respect of exports. The Earl of Listowel, supporting much that Lord Crook had said, added that the telephone service in Britain is backward because we have not put sufficient capital into the manufacture of telephone equipment and have not ensured for the Post Office the normal programme of capital development that any large business enterprise requires.

Replying for the Government on the debate, Lord St. Oswald assured the House that no limitation has been placed on research for electronic exchanges because of shortage of capital investment. It has been deliberately decided to employ different techniques in different functional sections of the experimental exchange at Highgate Wood, so that their merits can be compared from all points of view; the ultimate aim is an economic standard electronic exchange. Lord St. Oswald claimed that work is proceeding at high pressure to produce improved designs, so that British industry can retain its position in the forefront of telecommunication development and be able to offer in world markets electronic exchanges fully competitive with those of any other manufacturers. He pointed out, however, that development is not solely for export, and a besetting problem generally is the comparative lack of enthusiasm among telephone subscribers for anything new. The average residential telephone user makes less than one call a day on his instrument, and even putting business and residential subscribers together, the average is only 530 a year, compared with between 1,000 and 2,000 in Sweden, Canada and the United States. The Post Office, in conjunction with the University of London, has recently instituted a joint research programme into the sociology of telephone usage.

Research on Mental Health in Britain

The Minister of Health, Mr. E. Powell, in a written answer in the House of Commons on February 8, stated that after completing its full-scale review of mental health research early in 1959, the Medical Research Council established a new committee on clinical psychiatry, under Sir George Pickering as chairman, and one on the epidemiology of mental disorders, with Sir Aubrey Lewis as chairman. Each committee has appointed working parties to study special aspects of its field, such as the psychopathic personality, the value of drugs in psychiatry as assessed by clinical trials, and the use of national statistics of mental disorders. Of the total funds available to the Council for the past five years, the percentage spent on mental health research was as follows: 1956–57, 2·3; 1957–58, 1·8; 1958–59, 3·8; 1959–60, 4·4; 1960–61, 4·7.

Rostherne Mere, Cheshire, as a Nature Reserve

Rostherne Mere and some surrounding woodland in north Cheshire have been presented to the Nature

Conservancy by the executors of the late Lord Egerton of Tatton, in accordance with his wishes. The area is to be declared a National Nature Reserve. Thousands of ducks which have learned to rely on the Mere as a sanctuary will thus continue to have the strict protection given during Lord Egerton's lifetime. The neighbouring Tatton Park, with its meres, having already been handed over to the National Trust and the Cheshire County Council, will provide for the recreational needs of the public. The area given to the Conservancy consists of 195 acres, and a nature reserve agreement with the new owner and the farmers of land immediately overlooking the Mere will cover an additional 183 acres. The hydro-biology of the area is of great interest and its supreme value as a winter resort for wildfowl, as well as a breeding-place for certain aquatic birds, is partly due to the strict control over access and disturbance maintained by the late Lord Egerton. In spring and autumn many migrant birds may be seen there resting on passage, and some rare species have been recorded. The late A. W. Boyd carried out numerous and detailed observations there for at least forty years and his work has made a great contribution to our knowledge of its bird fauna, which his friends hope to commemorate by building an observation post overlooking the Mere.

Peak District National Park

THE third of the official guide books to Britain's National Parks has been prepared by the Peak Park Planning Board in association with the National Parks Commission, under the editorship of Patrick Monkhouse (*National Park Guides*, No. 3: Peak District. Pp. viii+90+26 plates. London: H.M. Stationery Office, 1960. 5*s*. net). Among the authoritative contributors is Lt.-Col. Gerald Haythornthwaite, who deals with the building traditions to be found in the Peak. Other contributions describe the geological structure and scenery of this National Park, its animal and plant life, and the marks made by man's occupation of the land since early times. There are also chapters on farming and industry in the Park to-day, as well as an account of the work done by the Peak Park Planning Board in preserving the beauty of the varied landscape and promoting its enjoyment. That the facilities of the Park are appreciated is shown by the way natives of grim industrial areas like South Lancashire, North Staffordshire and Sheffield seek solace in its open spaces. The guide book contains a gazetteer of places of interest which would be especially appreciated by visitors.

Changes in Sea-Level recorded in New Zealand

HUTTON'S doctrine that the present is the key to the past has been taken increasingly to heart by geologists in recent years. The sedimentary processes operating on the continental shelves and in various intertidal environments have received widespread attention since the War. Before older sedimentary rocks can be interpreted in terms of the Holocene, however, it is necessary to allow for any deviations from the norm which may have resulted from the Pleistocene glaciation. In particular, small changes in sea-level can influence sedimentation profoundly, and it is essential to determine any changes that have occurred as accurately as possible. Further evidence concerning world-wide fluctuations has recently been brought to light. In northern North Island, New Zealand, J. C. Schofield (*N.Z. J. Geol. and Geophys.*, **3**, 467; 1960) has been able to trace a number of elevated chenier ridges and to date the origin of several by radiocarbon determinations on shells. The area is believed to have been tectonically stable since the end of the Miocene period, so that the levels of the ridges may be interpreted in terms of changes in sea-level. Neglecting minor changes, the sea-level appears to have fallen 7 ft. from about 2000 B.C. to the beginning of the Christian era, and to have remained relatively stable since then. The changes correlate favourably with transgressional periods recorded in Europe. The present rise of 8–9 in. a century may well be only a minor fluctuation in what is now an essentially stable ocean-level.

Hatfield Technical College

As from September next Hatfield Technical College will be renamed Hatfield College of Technology. Three departments of engineering have recently been formed, namely: the Department of Mechanical and Aeronautical Engineering (head of department, D. R. Samson); the Department of Industrial Engineering (head of department, J. D. Smith); the Department of Electrical Engineering (head of department, B. F. Gray). It is also announced that Dr. R. F. Robbins has succeeded Dr. Fred. Lester as head of the Department of Science.

The Institute of Metals

THE Council of the Institute of Metals has made the following awards of medals for 1961: *Institute of Metals* (*Platinum*) *Medal*, to Major C. J. P. Ball, chairman of Magnesium Elektron, Ltd., in recognition of his outstanding services to the non-ferrous metal industries and, in particular, to the magnesium industry; *Rosenhain Medal*, to Dr. P. B. Hirsch, of the Cavendish Laboratory, Cambridge, in recognition of his outstanding contributions in the fields of physical metallurgy and metal physics.

The following have been elected officers and members of the Council of the Institute of Metals: *president*, Prof. H. O'Neill (head of the Department of Metallurgy, University College of Swansea, University of Wales); *past-president*, Sir Ronald Prain (chairman and president, Rhodesian Selection Trust, Ltd.); *vice-presidents*, Mr. W. F. Randall (deputy chairman and managing director, Telcon Metals, Ltd.) and The Right Hon. The Earl of Verulam (chairman, Enfield Rolling Mills, Ltd.); *ordinary members of Council*, Mr. N. I. Bond-Williams (managing director, the Aston Chain and Hook Co., Ltd.); Prof. A. H. Cottrell (Goldsmiths' professor of metallurgy, University of Cambridge); and Mr. G. A. Rider (deputy managing director, Birmid Industries, Ltd.).

University News: Birmingham

THE Ford Foundation has given the University a grant of 440,000 dollars to support a programme of research extending over the next fifteen years in the Department of Anatomy into the reproductive physiology of monkeys. The Department has been made the recipient of this benefaction because, under the direction of Sir Solly Zuckerman, work of this nature has been one of its main interests for many years.

London

The following titles in respect of the posts occupied have been conferred: Sir William Collins professor of anatomy in the University on Mr. G. W. Causey (Institute of Basic Medical Sciences); reader in veterinary physiology on Dr. F. R. Bell (Royal Veterinary College); reader in anatomy on Dr. A. S. Breathnach (St. Mary's Hospital Medical School); reader in geography on Dr. E. H. Brown (University College); reader in clinical rheology on Mr. D. G. Melrose (Postgraduate Medical School of London); reader in chemical engineering on Dr. J. W. Mullin (University College).

Southampton

Sir Basil Schonland, director of the Atomic Energy Research Group, Harwell, has been elected junior pro-chancellor in succession to the late Sir Henry Tizard.

"Fatigue Straining of Copper Whisker"

Dr. Edward Eisner has written with reference to the communication in *Nature*, **188**, 1183 (1960) directing attention to some misprints. "The units of stress in paragraph 1 should be kgm./mm.^{2}. The second sentence of paragraph 3 should contain the phrase '. . . with the whisker encastered in diphenyl carbazide glass . . . ' instead of the present phrase. This is intended to convey that a part of the whisker at one end was embedded in the glass, so that that portion of the whisker was rigidly held, approximately normally to the surface of the glass. The second part of the last sentence of paragraph 7 should read, ' . . . it afterwards withstood 10^6 cycles at 0·1·1 per cent and 10^6 cycles at 0·1·7 per cent strain, and it kinked after 10^5 cycles at 0·2·3 per cent strain'."

Announcements

Mr. Denzil Freeth, member of Parliament for Basingstoke, has been appointed Parliamentary Secretary to the Minister for Science, and will answer in the House of Commons for the Lord President of the Council and the Minister for Science.

Sir Edward Appleton has been awarded the Gunning Victoria Jubilee Prize for the period 1956–60 of the Royal Society of Edinburgh for his distinguished contributions to ionospheric and radio physics.

Mr. Brian G. Robbins, secretary of the Institution of Mechanical Engineers, is to retire on June 1 and will be succeeded by Mr. Kenneth H. Platt, at present deputy secretary of the Institution. Mr. Platt, who is a graduate of the University of Glasgow, has been associated with engineering education and training, both in industry and with the Ministry of Education.

The French Government is offering again this year scholarships for further study or research in France. The grants will be given for periods of 3–10 months during the academic year 1961–62. Candidates should hold a degree or equivalent qualification. Applications from graduates in science or medicine will be particularly welcome. Application forms and further information can be obtained from the Scientific Office, French Embassy, 22 Wilton Crescent, London, S.W.1. The closing date for application is March 16.

The Trustees of the Ramsay Memorial Fellowships Trust will consider in June applications for a Ramsay Memorial Fellowship for advanced students of chemistry. The value of the fellowship will be £700 per annum, to which may be added a grant for expenses of research not exceeding £100 per annum, and it will normally be tenable for two years. Completed application forms must be received by the Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College London, Gower Street, London, W.C.1, not later than April 17.

The Institute of Physics and the Physical Society is arranging a conference on "Palæomagnetism", to be held at King's College, University of Durham, Newcastle upon Tyne, during April 20–22. Further information can be obtained from the Administrative Assistant, Physics Department, King's College, Newcastle upon Tyne.

An international symposium, entitled "Host Tumour Interactions", is to be held at the Henry Ford Hospital in Detroit, Michigan, during May 18–20. Further information can be obtained from Dr. Michael J. Brennan, Oncology Division, Secretary, Symposium on Host Tumour Interactions, Henry Ford Hospital, Detroit 2, Michigan.

The Unesco South Asia Science Co-operation Office is organizing a regional seminar on "Scientific Documentation", during March 7–16, at the Indian National Scientific Documentation Centre, National Physical Laboratory, Hillside Road, New Delhi. Further information can be obtained from Unesco South Asia Science Co-operation Office, 21 Curzon Road, New Delhi.

The Council for British Archæology is organizing a conference on "Prospecting in Archæology by Geophysical Methods" in collaboration with Dr. J. C. Belshé, Department of Geodesy and Geophysics, University of Cambridge. The conference will be held in the Institute of Archæology, 31–34 Gordon Square, London, W.C.1, during March 4–5. Further information can be obtained from the Council for British Archæology, 10 Bolton Gardens, London, S.W.5.

A discussion conference on "Science and Education" is being arranged by the Association of Scientific Workers, Association of Teachers in Technical Institutions, Association of University Teachers, National Union of Teachers and Science Masters' Association, and will be held at the Mahatma Gandhi Hall in London on March 11. Correspondence in connexion with the conference should be addressed to the Conference Secretary, c/o Association of Scientific Workers, 15 Half Moon Street, London, W.1.

A one-day symposium on "Computers for the Chemical Engineer" is to be held in the University of Birmingham on March 28. It is being organized by the Graduate Section of the Birmingham University Chemical Engineering Society and the Graduates and Students Section of the Institution of Chemical Engineers, Midlands Centre. Further information can be obtained from the Registration Secretary, Department of Chemical Engineering, University, Edgbaston, Birmingham, 15.

Writing with reference to the communication entitled "Spontaneous Cytomegalic Inclusion Body Disease involving Lacrimal Glands of Caesarian-derived (so-called) Pathogen-free Rats", in *Nature*, **188**, 506 (1960), Dr. Hans Meier states the animals used were not ". . . raised in the Roscoe B. Jackson Laboratory", but in the laboratories of the Children's Cancer Research Foundation, Boston, where the work was carried out.

THE 1961 EXHIBITION OF THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

THE forty-fifth Annual Exhibition of Scientific Instruments and Apparatus held in the Old and New Halls of the Royal Horticultural Society in London during January 16–21 was the first since the amalgamation of the Institute and the Society. By continuing in its established tradition, it has incidentally managed to conform with ancient precedent, for the sixth King James of Scotland also suffered no change of character on becoming the first of a united body. It was propitious that the activities and publications of the Institute and Society were displayed conspicuously on an attractively arranged stand, and many visitors must have been glad of this opportunity to make a closer acquaintance with their host. From the point of view of learning about new developments, it was a very good exhibition. The footnote 'demonstration' in the catalogue usually meant not just that a device would be working, but that an experiment to explain its principle or its uses had been mounted. Things progress so fast nowadays that even the term 'trend' would be out of place (if it has not already been registered to name a detergent, anyway); and the uninitiated can only hope to sense what is more like a rate of increase of acceleration. This seemed steepest in fast-operating elements for computers, instrumentation for thermonuclear research, and micro-wave amplifiers, all directed towards the future; and in physics applied to archæology, using nuclear and other techniques for raking up the past.

Several stands exhibited devices incorporating the new Esaki or 'tunnel' diode, made of germanium antimonide or indium antimonide; this operates by a quantum-mechanical tunnelling across the energy gap at a p–n junction, and its chief virtue is high speed. Its uses in logic and memory circuits and for amplitude–time discrimination were shown. The Royal Radar Establishment illustrated the behaviour of a tunnel diode in a magnetic field, which alters the energy gap and reduces the current. Microminiaturized solid circuits, and also circuits built up from thin films, were displayed. Among new ceramic materials were those designed for capacitors, high-temperature ceramics of the silicon nitride and silicon carbide type, and ceramic elements for electroluminescent panels.

Thin magnetic films, using material of the permalloy type, are made for information storage and millimicrosecond switching elements. Two firms demonstrated apparatus for determining the hysteresis loops of thin films, and for observing the domain boundaries visually by means of the Kerr magneto-optical effect. The General Electric Company showed how the easy direction of magnetization can be determined, and also a device for testing magnetic-film matrix elements under simulated computer conditions.

How to deal with the 14-MeV. neutrons resulting from the (D,T) reaction is one of the problems of the thermonuclear investigators, and three neutron generators producing 14-MeV. neutrons by bombarding tritium-containing targets with 100-kV. accelerated deuterons were displayed, for either pulsed or steady operation. These will enable studies of this interesting product of the (D,T) reaction to be made at high flux densities without having to operate *Sceptre* and such-like as sources. Associated Electrical Industries, Ltd., of Aldermaston, showed a data-processing system for thermonuclear research, following the fluctuations of an unstabilized discharge in a glass torus, intended to study what goes on in *Sceptre* itself.

Amplification of various kinds was featured in many exhibits. Five-stage optical image intensifiers, using secondary emission from thin-film dynodes and amplifying up to 100,000 times, represent one aspect; and there were many micro-wave low-noise and other amplifiers. Standard Telephones and Cables, Ltd., illustrated the principle of the parametric amplifier by a mechanical analogue; and there was a parametric amplifier for ultra-high frequencies which operated after frequency conversion down to the X-band. I learned from a physicist working in this field that the maser of the future for satellite and space work is the travelling-wave tube—of the immediate future, that is. Production types of travelling-wave tubes were shown, and the Services Electronics Research Laboratories had a high-power version which operated at about 5 kW. This establishment also had a cyclotron wave-amplifier (Adler tube); and Associated Electrical Industries, Ltd., featured what was called a quadrupole electrostatic cyclotron wave-amplifier, which has not so far reached the stage of being a low-noise device.

Fundamental physics was exhibited in the demonstration arranged by the Atomic Energy Research Establishment of the Mössbauer effect, in which the γ-rays emitted by one transition in an excited iron-57 nucleus are absorbed by a different transition in an iron-57 target moving at a suitable relative velocity, the resonance being displayed on a velocity spectrometer. Among the exhibits from the National Physical Laboratory was a new absolute radiometer, determining radiant power in terms of electrical power. What might almost be called 'unfundamental physics' was shown in a piece of intriguing hydrometry, which used a thin-walled transducer vibrating within a liquid to determine the density of the liquid to better than 1 per cent—valuable for the particular kind of instrumentation that it was aimed to do, of course, but a long way round in principle.

Magnetometry was represented by proton-resonance magnetometers; one by Mullard, Ltd., adapted to control the oscillator at what the description consistently and nostalgically called the "Lamour frequency", and another as part of the comprehensive exhibit of the Research Laboratory for Archæology and the History of Art, Oxford, where one would have liked to spend a good deal longer learning about the highly ingenious stratagems used to detect buried buildings and pottery by measuring the small changes they produce in the ambient magnetic field and its vertical gradient; it was amazing to learn that the real source of this change is in many cases the result

of a slight alteration in the magnetic properties of clay produced by firing. The Signals Research and Development Establishment demonstrated a rubidium-vapour magnetometer, which is best described as the optical-pumping (or 'photon-spin pumping') device working in reverse. The effect of a magnetic field, which separates the otherwise degenerate spin-levels by an extent proportional to this field if it is small, is used to measure the strength of the field. A perpendicular radio-frequency magnetic field is adjusted to the energy difference between the pair of levels which have been population-inverted (that is, to the Larmor frequency when the system starts to operate maser-wise, a state that is detected by the strong absorption of the pumping beam of circularly polarized rubidium D_1 light). Thus, instead of tuning to a given radio-frequency by altering the field, the system is tuned to the ambient field by altering the frequency. This is sufficiently sensitive for geomagnetic observations, and may possibly be applied to aerial and space magnetic surveys; indeed, the actual apparatus was too sensitive to work in the disturbing fields of the Hall, and was planted out on the Westminster School playing-field.

These are the impressions of a day's visit; a proper appreciation would have needed the full five days, and some considerable preparation beforehand. There was much that I missed, and one highlight in the form of a miniature lighthouse with a brilliant source that I even failed to identify properly. The exhibits from various research laboratories of the Department of Scientific and Industrial Research were representative of the wide variety of tasks they undertake. The Science Museum had two exhibits, one ancient and one modern, and there were six contributions from university departments; it would add further facets to a brilliant occasion if we could see, among all the new tools for research and development, more of the new apparatus designed at the universities for their practical classes and demonstrations, and at the Science Museum for the instruction of the general public.

Evening discourses were given during the Exhibition by F. S. Burt, on "Hydrodynamics Research"; by Dr. G. E. R. Deacon, on "The Physics of the Ocean"; and by Dr. F. P. Bowden, on "Some Physical Problems in Travelling at Supersonic Speed".

G. R. Noakes

CALORIE BALANCE IN MAN

THE one hundred and thirty-seventh meeting of the Nutrition Society was held in the Middlesex Hospital Medical School on December 17, and took the form of a symposium on "Calorie Balance in Man". Perhaps it was optimistic to expect a symposium, continuing from 10.15 a.m. to 4.30 p.m. on the Saturday a week before Christmas, to be popular. In fact, it was a well-attended meeting with an audience of more than 100. The chairman was Sir Charles Dodds.

Not so many years ago the subject of "Calorie Balance" would have been an unlikely topic for such a symposium. Interest in calories, at least in relation to human energy, was at a low ebb scientifically and a rather naive idea was prevalent that little now remained to be discovered in this field. Far from this being the case, a most notable impression gained from the speakers at this symposium was the great dearth of reliable relevant information.

The lack of information and the misconception about many aspects of human energy metabolism were mentioned in relation to some of the "Basic Physiological Factors affecting Calorie Balance", the title of the paper by Dr. J. V. G. A. Durnin (University of Glasgow). Part of the complexity of 'calorie balance' arises because of the difficulty of assessing methodological accuracy; there is no sure way of knowing whether the intake of calories or the expenditure of energy represents the 'normal' or usual state for the individual subject. He, or she, may be eating more or less, during the experimental study, than would normally be the case, or the level of energy expenditure may be altered. Since it is extremely difficult under field conditions to carry out such measurements over a period of more than a few days, theoretically one possible way of finding a departure from the normal would be to measure a change of weight in the subject. Part of this paper and a large part of the discussion were devoted to the balance of weight, and Dr. Durnin showed results for young men, weighed under highly standardized conditions, where their gross body-weight changed by up to 3 lb. (1·4 kgm.) from day to day. Such changes, presumably almost entirely due to alterations in the fluid content of the body, make the weighing of subjects quite worthless in regard to the balance of energy.

Other factors dealt with were exercise (so often discussed emotionally rather than rationally), climate, age (growth in the young and inversion of growth in the old) and the efficiency of utilization of food by the body.

That most of us do not normally attain balance of energy from day to day was shown clearly by an analysis on the results for 69 individuals, where only 4 subjects had a significant correlation between their intake and output of energy; our 'appetite' is a fickle mechanism.

Calorie balance is probably a long-term control, which may be effected by centres in the hypothalamus responding to changes in the fat depots of the body and then influencing the general level of food intake and perhaps even of bodily activity. In this control, the reticular activating system of the brain stem, the limbic system and the hypothalamus may act together. This was suggested by Dr. G. C. Kennedy (University of Cambridge) in his paper "Central Nervous Regulation of Calorie Balance". The importance of exercise was stressed, both in relation to man and to studies on animals; much work on rats or mice is not comparable because of varying levels of physical activity resulting from restrictions imposed by some types of animal cages. Similarities between a 42 stone (267 kgm.) obese patient and experimentally obese rats were shown by both the astonishing hyperphagia and also lack of resentment or discomfort when food was restricted. They were also alike in their inactivity.

It has been the custom, at certain levels of medical therapeutics, to treat obesity as if it were primarily an endocrine disorder and give the patient mixtures of tissue extracts from various endocrine glands.

The traditional blame attached, by many clinicians, to the endocrine system in the causation of obesity was repudiated by Dr. Raymond Greene (London) in "The Effects of the Endocrine System on Calorie Balance in Man". The several endocrine glands were considered in brief, abnormalities of some of them being associated with modifications in the water content of the body; occasionally obesity occurs concomitantly with endocrine pathology but rarely, he thought, is hormonal disorder of any great importance. Dr. Greene suggested that a more interesting discourse, rather than the prescribed one, might have been on "the influence of nutrition on the endocrine system".

Within recent years some changes in outlook on the nature of fat metabolism have been apparent. It has been suggested, although not always with convincing experimental evidence, that the fat depots of the body are far from inactive tissues and indeed are continuously being mobilized. Their nerve supply is stated to be extensive, although most histologists appear to have some difficulty in finding many nerve endings, as opposed to nerve fibres, in adipose tissue. Prof. A. Kekwick and his colleagues have been engaged in studying the "Metabolism of Adipose Tissue", the subject of a paper by Dr. T. M. Chalmers (Middlesex Hospital, London). He suggested that free fatty acid and not glucose might be the principal energy substrate, because of its rapid turnover in the plasma. The fat-mobilizing substance, found in the urine of fasting men, might have some physiological role; its release in the urine apparently depends on carbohydrate metabolism, this being demonstrated in one obese patient treated with equicalorific diets containing varying amounts of carbohydrate.

The second half of the meeting began with a paper on "Energy Expenditure and Calorie Intake in Young Men" by Dr. O. G. Edholm (Medical Research Council, London). In a series of 6 surveys, on 54 Army recruits, he had found variations in energy expenditure of from 2,200 to 6,100 kcalories/day and of intake from 671 to 8,750 kcalories/day, with means of about 3,800. The lack of agreement between calorie balance and the weight balance of the body was again stressed, when these were measured over periods of a few days. There is not sufficient information at present to determine the effect, if any, of severe cold on calorie balance. Work carried out in the Antarctic has shown that men put on weight in the winter and lose weight in the summer; this might be due to climatological factors, but equally well might reflect different social circumstances.

The amount and the rationale of the extra "Calorie Requirements in Pregnancy" were discussed by Dr. A. M. Thomson and Dr. F. Hytten (University of Aberdeen). From a series of several hundred healthy primiparæ studied in Aberdeen, it seemed that an average of about 4 kgm. of fat was added to the mother's tissues by the time pregnancy ended. This is almost certainly physiological, and is required to help the mother in the needs of lactation; however, if breast-feeding is becoming much less common, as appears to be true in Western society, this extra gain in weight may predispose to future obesity. The authors emphasized the small amount of experimental information on the exact increase in food taken during pregnancy and the degree of the changes, if any at all, in the amount of physical activity of the woman; this has a considerable bearing on any extra allowance recommended.

From the interesting paper by Dr. E. M. Widdowson (University of Cambridge) on "Energy Balance in Early Life", new-born babies are frequently subjected to considerable stress by deprivation of food. When this happens, the fat stores of the body are quickly used up, particularly if the baby is required to maintain a high metabolic rate. This will be necessary if the environmental temperature does not fall within the critical range 32-35° C. Babies appear to be as variable in their energy expenditure as adults, and it seems unphysiological to expect all babies to require similar quantities of food.

The discussion of the papers was relevant, interesting and prolonged; the meeting was a most successful one.

J. V. G. A. Durnin

WATER IN AUSTRALIA

Man's existence depends on an adequate supply of water, and in Australia, as in few other countries, future development will depend on using water resources to the full. An important step in the utilization of water is the understanding of its properties, and the Victorian Branch of the Royal Australian Chemical Institute found no difficulty in attracting some fifty scientists from four Australian States, whose interests ranged from engineering to biology, to a three-day discussion on this broad topic. The meeting was held at Warburton, Victoria, in late November.

In the opening talk Dr. J. A. Barker reviewed the structure of hydrates and of ice as an introduction to the loosely packed structure of liquid water in which the molecules are prevented from coming into closest proximity by tetrahedrally arranged hydrogen bonds. Each pattern of hydrogen bonds persists for periods of the order of 10^{-12} sec. The theory of Pople, based on this picture, would require each water molecule to have 4 nearest neighbours, 12 next nearest and 36 third nearest, whereas the corresponding figures obtained from analysis of X-ray diffraction data are 4, 11 and 22. Dr. Barker contrasted the anomalous properties of water that result from this structure—the decrease in solubility of gases with increasing temperature, the high negative temperature coefficient of viscosity—with the properties of more normal liquids in which the molecules are closely packed.

Evidence consistent with this structure was presented by Dr. S. D. Hamann, who described some of the effects of pressure on the properties of water and showed how many of the anomalies disappear as the molecules become close-packed at pressures greater than 2,000 atm. Thus with increasing pressure the thermal expansion of water became 'normal', its sound absorption decreased as pressure broke down its structure, and its dielectric constant decreased. Measurements of the conductivity of water under pressures up to 130,000 atm. had produced increases in ionization so that its conductivity equals that of a 5-*N* solution of hydrochloric acid. Pressures of this order are probably reached at depths of 400 km. in

the Earth and the enhanced ionization therefore has interesting geophysical implications.

Dr. P. W. Posener showed how microwave spectroscopy could be used to fill in details in the above broad picture.

Considerations of the electronegativity of the oxygen atom in water and hydrates, in both the normal and excited states, led Dr. J. F. Duncan to certain novel and controversial generalizations on the oxidation properties of water. Subjects as diverse as the thermodynamic properties of aqueous ions, the radiolysis of water and the kinetics of aquation reactions could be described semi-quantitatively.

Prof. R. C. L. Bosworth reminded the meeting of the experiments of Nukiyama on the boiling of water, first described in 1934 but disregarded for some fifteen years. A study of boiling produced by a heated platinum wire immersed in water, relating the heat input to the temperature of the wire, revealed three distinct zones of boiling, sometimes with discontinuities between them. The phenomena described by Prof. Bosworth clearly have important practical implications for the design of boilers and heat exchangers. Dr. K. L. Sutherland suggested in discussion that the variation of contact angle with applied potential that had been observed by Frumkin could perhaps be used in controlling boiling. By causing an applied potential to fluctuate at a predetermined rate it might be possible to alternate the periods of bubble formation (large contact angle) with those of bubble release (zero contact angle).

Dr. G. F. Walker described some vermiculite–butyl ammonium ion complexes, their swelling in water, and the intriguing behaviour of their swollen forms. The 10-Å. thick silicate layers, 4 mm.^{2} in area, remained parallel to each other even at interlayer spacings up to 600 Å. The interlayer spacing depended on the concentration and type of cations present and could be varied reversibly under the influence of an electric potential. The phenomenon lacks, as yet, a full theoretical explanation and may have novel applications as a variable molecular sieve.

"Water in Australia" was the topic chosen by Mr. L. R. East in opening the part of the meeting that dealt with conservation. Conservation in Australia poses special problems; an average rainfall of 16·5 in. compared with the average of 26 in. for all land masses, the large area and small population, and the combined influence of the great variations of rainfall in good and bad years—and of the disastrous reduction of the proportion of rain-water finding its way into the rivers in years of drought. He contrasted the lack of a national water policy in Australia, in spite of significant nineteenth-century contributions, with that initiated in the United States by Theodore Roosevelt in 1901, when he stated that "The reclamation and settlement of arid lands will enrich every portion of our country. . .".

Mr. East discounted the possibility of affecting the climate of neighbouring areas by constructing large inland dams. In this he was supported by Dr. C. H. B. Priestley, who said that, although man had undoubtedly affected weather by his clearing and cultivation of millions of square miles, localized activities were unlikely to have an appreciable effect. He used measurements made over the Mississippi basin to illustrate the balance of water in the atmosphere and showed that up to 90 per cent of the rainfall came from maritime air and only about 10 per cent from continental air.

Mr. E. J. Smith brought the meeting up to date on the progress of rain-making research in Sydney, and pointed out the gaps which exist in the understanding of the nucleation process. In particular, he stressed the possible importance of the particle size of the nuclei as it affected their ability to promote ice-formation and their decay by photolysis and other mechanisms.

Advances in evaporation control with cetyl alcohol were described by Mr. W. W. Mansfield. For large areas of water the alcohol is dusted on to the surface by a grinder-duster, and from the particles a film spreads over the surface. Evaporation, under ideal circumstances, can be reduced by as much as 40 per cent, but the method becomes much less effective as the wind velocity increases. The cost, based on a test at Broken Hill, was one penny per thousand gallons saved.

Two methods of reducing the salt content of water were described by Messrs. R. B. Cooper and L. S. Herbert. Electrodialysis, described by Mr. Cooper, can be used economically to reduce the salt content of water from about 4–5,000 p.p.m. to 3–500 p.p.m. The power needed may be between 9 and 40 kW.hr./1,000 gallons, depending on the salt content and on the flow-rate required. Mr. Herbert discussed some aspects of the distillation of sea-water and suggested possible techniques to improve the efficiency of the process, particularly in increasing heat transfer coefficients. The theoretical minimum energy for any such process is about 3 kW.hr./1,000 gallons, but the practical minimum is about 12 kW.hr./1,000 gallons, a figure which is still far from realization. With known technology it should be possible, on a sufficiently large scale, to produce fresh water for 8*s*. per 1,000 gallons and eventually, with improvements in technique, to reduce this to about 4*s*. per 1,000 gallons.

Mr. J. W. Legge considered the physical-chemical properties of water in relation to the origin and evolution of life, and to L. J. Henderson's views on the fitness of the environment. Knowledge of film stability on natural water surfaces could throw light on current controversy about the kinetics of the synthesis of primitive proteins. He outlined current biochemical views of the splitting of water in photosynthesis and the recombination of hydrogen and oxygen in the aerobic cells.

The movement of water-solute through cell walls was related by Dr. L. R. Finch to the current picture of the membrane. The vesiculation observed in electron micrographs of thin sections, as well as the phenomenon of pinocytosis, involve, of necessity, changes in concentration at the interface. Accelerated metabolism of phospholipids could be shown to take place during such transport processes.

A good deal of discussion followed the contributions of Dr. J. R. Philip and Prof. J. H. Green, which were related to the theory and measurement of groundwater flow. Models for the process are complicated due to changes in the nature of the medium with water content, but Dr. Philip showed how they had been reduced to a tractable form by making use of the basic Navier–Stokes equations. Many were surprised by the high rates of ground-water movement which have been measured by observation of consciously and adventitiously added radioisotopes.

It is pleasing to report on a conference which aroused so much discussion, both formal and less so, and from which so many new patterns of collaboration promise to emerge.

POLITICAL AND ECONOMIC PLANNING IN PAKISTAN

A BROADSHEET recently issued by Political and Economic Planning deals with Pakistan's second Five-year Plan*. After reviewing the first Five-year Plan, it describes briefly the size and objectives of the second Plan and the aims of the various sector programmes, concluding with a brief critique. The fundamental problem for the second Plan is, under severely limiting conditions, to liberate the people from the crushing burden of poverty by ensuring that the rate of growth of the economy exceeds the present 2 per cent annual increase in population. The second Plan, amounting to 1,900 crore rupees, is about 75 per cent larger than the first, a real increase of about 50 per cent, and the methods used are a development of those employed in making the first Plan. Within the various sector programmes, priority is given to schemes already in an advanced state of preparation, or which have already been the subject of foreign government aid; the emphasis is on schemes designed to give quick returns through the better use of existing resources.

Essentially the Plan seeks to make maximum use of the market mechanism, and to employ fiscal and monetary measures rather than direct controls. It adopts a pragmatic approach as between public and private development, with public investment supplementing, rather than displacing, private enterprise, and seeks to develop labour-intensive rather than capital-intensive methods, where a choice is feasible, according to the relative real scarcities of the factors of production. Only a limited call is made on the extra wealth of the community, as the economy progresses, for still further investment, and within the broad priorities of the programmes proposed a substantial element of flexibility has been built into the Plan to meet unforeseeable changes. Of the numerous programmes, those aimed at developing education, health and social welfare services (estimated to cost some 130 crore rupees), like the housing programme, would seem to be out of scale with the needs when judged by contemporary standards and are limited by the resources available. It may be observed that during 1960–65 it is proposed to improve existing social services and to inaugurate schemes for research and training social workers, as well as to attack vigorously such main diseases as malaria, tuberculosis, smallpox and leprosy, to improve greatly the existing schools in East Pakistan, provide more in West Pakistan and extend and improve the universities, as well as extend technical training.

Although the second Plan is regarded as ambitious in the Broadsheet, and requiring devotion, intelligence and hard work if it is to be applied effectively, it is not considered wildly out of scale with the resources, foreign and indigenous, likely to be available. A great effort has been made to improve both the personnel and the systems of administration; a new generation of administrators has been trained and is gradually displacing weak elements from senior positions, while there is some sign that foreign managerial expertize is more warmly welcomed. There is a critical shortage in skilled technicians of all kinds, and a good deal of dilution and improvisation will be needed as well as the full and most effective use of whatever foreign technical services may be available. By and large, it is difficult to find the Plan unsuitable, in any major respect, to Pakistan's needs to-day. There is justification for taking seriously the Government's avowed intention to create a system of democratic government well suited to the conditions of Pakistan. The fact that the second Plan is prepared to tackle the thorny problem of family planning by including a family planning programme of national propaganda, with clinics at all hospitals, dispensaries and maternity centres estimated to cost 3 crore rupees, is regarded as the most hopeful single pointer to the prospect of successful planning in Pakistan.

* *Planning*, Vol. 26, No. 446 (7th November, 1960): More Planning in Pakistan. Pp. 309–336. (London: Political and Economic Planning, 1960.) 3*s.* 6*d.*

RADIO RESEARCH DURING 1959

THE report of the Radio Research Board and of the Director of Radio Research for 1959 summarizes the wide range of work carried out at the Radio Research Station, Slough, and at the substation in Singapore*.

The report of the Board refers to the recent revision of the structure and terms of reference of its committees in order to ensure that they adequately cover present and future research activities in the radio-field. Considerable emphasis is laid on the importance of radio in space research, and it is planned that in the immediate future about 50 per cent of the effort at Slough shall be devoted to such research. Details of the research work at the Station during 1959 are given in the report of the Director.

Some preliminary work on data obtained during the International Geophysical Year has been done, and this includes an analysis of data on the incidence, at high-latitude stations, of polar radio 'blackouts' and of polar sporadic-*E* ionization. The results show that these phenomena are produced by solar-particle streams incident on the upper atmosphere along arcs which are similar to the precipitation spirals predicted by Störmer fifty years ago.

A study has also been made of the International Geophysical Year data now available for Slough, Singapore and Ibadan on atmospheric radio-noise. The Slough observations provide detailed information on noise characteristics at four frequencies in the range 20 kc./s.–20 Mc./s. The differences between noise-levels at Slough and Singapore are such as would be expected from known differences in meteoro-

* Department of Scientific and Industrial Research, 1959: The Report of the Radio Research Board and the Report of the Director of Radio Research. Pp. iv+34+4 plates. (London: H.M. Stationery Office, 1960.) 3*s.* net.

logical conditions; but the noise-level at Singapore is not so intense as might be expected from its close proximity to one of the main thunderstorm areas of the world. Work on atmospherics from local storms is providing information on the power distribution with frequency in the lightning flash, and on the extent to which the wave-forms of the radiated disturbances can be explained in terms of the lightning mechanism.

The day-to-day variability in the electron densities of the various ionospheric layers is largely due to the corresponding variability in the wave and particle radiation from the Sun. The derivation of ionospheric indices of solar activity is of special importance for prediction purposes, and the report describes work which has been carried out on such indices for the *E* and *F*2 layers. As part of the International Geophysical Year Calendar Record, *E*-layer solar ionizing radiation indices, *F*2-disturbance indices and polar blackout indices have been calculated for each day of the International Geophysical Year. These daily indices should be invaluable for studies in other International Geophysical Year disciplines.

A rapidly increasing proportion of the activities of the Station at Slough is being devoted to various aspects of space research, and considerable observations have already been made on the direction of arrival of signals from satellites and on the received signal characteristics (Doppler shift, Faraday rotation, telemetry). The station also provides some 100 establishments and observers with predictions, at weekly intervals, of the times and directions of transit of satellites passing within radio-range of observers in the British Isles. Similar work is also being carried out at the Singapore sub-station.

In the radio-measurements and standards field the research and development have been concentrated mainly at frequencies greater than a few hundred megacycles per second. The Station has acted as the co-ordinating centre for the international comparison of milliwatt power-measuring techniques at centimetre wave-lengths, and satisfactory agreement has been found between measurements made with instruments of different types used in the standard laboratories of the United States, Japan and the United Kingdom. Recognition of the possible harmful biological effects of high-intensity electromagnetic radiation at frequencies greater than about 50 Mc./s. has called for the development of reliably calibrated instruments to measure the flux density near high-power transmitters, and the report refers to work being carried out to meet this need.

The study of long-distance ionospheric transmission characteristics, using a sweep-frequency pulse technique, has continued and been extended to a 6,700-km. path between Ascension Island and Slough. It is found that during the daytime the modes of transmission are always very complex because of reflexions from tropical sporadic-*E* ionization, and the sunset deterioration and fading of signals from stations in equatorial latitudes is associated with the break-up of this sporadic ionization at such times. Work on the lateral deviation of signals from Japanese short-wave stations shows that there are often periods when the signals depart significantly from the great-circle path and that propagation by way of auroral reflexion is probably a common feature of night-time propagation over these paths.

Tropospheric radio-wave work includes studies of scatter propagation, delay times on microwave links and the refractive properties of the lower atmosphere. Extensive signal-level, gain in height, fading and diversity measurements have been made over distances from 130 to 400 km.; but it would appear that no completely satisfactory explanation of troposphere scatter propagation is yet available. The bandwidths which can be used in short point-to-point microwave communication links are limited by multi-path propagation, and equipment is being developed at Slough to enable accurate detailed work on the signal-delay times to be measured. The refractive properties of the lower atmosphere are being investigated by means of airborne refractometer measurements, by radar sounding and also by using pressure, temperature and humidity data obtained from a balloon-borne wired-sonde.

Research at the Station on semiconductors has been mainly on transistors and their application. Microwave measurements on certain ferrite–aluminates in a resonant cavity and on transmission phenomena in wave-guides containing these materials has continued.

This 1959 report is of particular interest in that it is the last annual report of Dr. R. L. Smith-Rose, consequent on his retirement from the post in September 1960.

W. J. G. Beynon

SAFEGUARDING HEALTH IN LONDON

THE annual report on the work of the Scientific Branch, Public Health Department, London County Council, has been prepared by Dr. S. G. Burgers, scientific adviser to the Council*. The Department has 64 members of whom 34 are graduates, and the work covered by them during 1959 varied from routine analysis of foodstuffs—still very necessary—to investigating the properties of cleansing materials used in kitchens and laundries. Much research of a fundamental nature is carried out and opens up many possibilities for economic exploitation. The Council is to be commended for the high quality of the investigations carried out by this section of its staff.

Particularly valuable research was connected with the treatment of sewage. How to produce sulphur from sulphate-enriched sludges was investigated by one team, and valuable information was obtained about the cost and practicability of the process, if conditions of national emergency should render its use necessary. Because of the long duration of these experiments, useful information was also accumulated about the effect of sulphide sludges on metal and other components of the experimental plant. Metals were found to be singularly free from corrosion—stainless steel was as bright after three years exposure as it was initially, mild steel and cast iron (partly protected by calcium carbonate scale) were scarcely affected and steel bolts immersed for eighteen months could be unscrewed with ease. Brass and lead,

* London County Council. Public Health Department—Scientific Branch. Annual Report of the Scientific Adviser for the year 1959. Pp. 46. (London: London County Council, 1960.) 1s. 3d.

except for a slight discoloration due to a sulphide film, were almost unaffected, but the zinc coating on the galvanized iron heating coils had completely disappeared, although this may have been due to electrolytes other than sulphides. Rubber was apparently unaffected.

Experiments were also continued on the final disposal of concentrated foam liquids, with particular reference to stripping by means of activated carbon. Aqueous solutions of 1,000 p.p.m. of sodium tetrapropylene benzene sulphonate were passed through a column of 1 in. diam. and 8 in. long, containing 100 gm. of activated carbon. The carbon was soaked in water before use, and care was taken to maintain the liquid level half an inch above the carbon column. During continuous flow the activated charcoal showed almost complete adsorption of the detergent present in the solution in the early part of the test; it was capable of extracting about 90 per cent of the detergent after it had adsorbed 27 per cent of its own weight of surface-active material and could still extract 50 per cent after adsorbing 38 per cent of its own weight. In a later experiment, a solution of 1,000 p.p.m. of sodium tetrapropylene benzene sulphonate in the final effluent from an activated sludge plant was passed through a column containing 100 gm. of activated carbon. A gauze pad was used to intercept suspended solids before the liquid reached the activated carbon in order to avoid choking the interstices in the column. Although adsorption was good, there was evidence that the carbon failed more quickly than when aqueous solutions were used, probably because of adsorption of other constituents of the effluent.

As activated carbon is expensive, attention was given to the possibility of regenerating the material. Attempts to displace the surface-active materials with solvents had only a limited success, and acidification of the dried exhausted carbon, followed by extraction with trichlorethylene, resulted in the removal of only a small proportion of the synthetic detergent in the form of its sulphonic acid.

The most promising method of disposal of condensed foam liquids appeared to be by spraying the foam with surface-activated sludge and allowing the solid content of the material to settle. In the process, the detergent concentration of the supernatant liquor might be expected to be reduced from about 500–600 to 30–40 parts per million, which could easily be treated by admission to primary sedimentation tanks.

Continuing a long-term investigation into the incidence of air pollution, volumetric instruments again indicated a reduction of 7 per cent in the average concentration of smoke in the air of London during the year, and this progressive tendency for improvement has continued since the inception of the Clean Air Act at the beginning of 1957. The sulphur dioxide concentration, for the first time, showed a similar reduction. The improvement was mainly attributable to exceptionally good weather in December, in which the average smoke concentration was only half the usual figure. It is probable that mild weather at the end of the year resulted in reduced domestic coal consumption, and, if this is true, the improvement may not be permanent. It is of interest that during the unusually fine summer the degree of pollution, though naturally low, was very similar to that of the previous cold, wet summer.

A five-month investigation into conditions at Camden Depot was completed, showing that a house adjacent to the railway was subjected to concentrations of black smoke and sulphur dioxide which were on the average 102 and 43 per cent respectively higher than the general London-levels. With the wind in certain directions, the average concentrations rose to at least 200 and 100 per cent respectively above the same London-levels. The situation is expected to improve with the gradual replacement of steam by Diesel locomotives.

RESEARCH IN THE SOCIAL SCIENCES

PRIORITIES for research in the social sciences in industry have been indicated by A. B. Cherns, head of the Human Sciences Section, Department of Scientific and Industrial Research (*Personnel Management*, **42**, No. 353; December 1960). In the field of ergonomics, for example, Cherns suggests that the man–machine relationship is a vital aspect of the study of man in industry. The social implications of the man–machine system are such as to justify more attention from social scientists perhaps as members of mixed ergonomic and sociological teams. Ergonomics is a field in which practical applications are easy to appreciate.

The development of adequate criteria of industrial relations should receive a high priority. Have the criteria also to develop indicators? Could the industrialist be advised what chart he should put on his wall to give him a guide to the industrial relations formulated in his plant? Until this be done, the claim to have extracted the full practical value from research cannot be substantiated. A wide comparative study would seem to be required.

The approach of Flanders and others, which aims at developing a study of industrial relations in all its aspects—economic, legal, psychological, sociological and historical—may well provide the stimulation that is needed both to give point to and to encourage wide comparative studies.

There has been an uneasy tug-of-war between interpretations of workshop behaviour based on views of the man in the workshop as an economical and rational animal and those based on views of him as a nexus of social roles—the economic and the sociological points of view. More accurate and systematic observation is a high priority—but not of the extended, reporting type with platitudinous conclusions.

More analysis of the pressures on the individual in industry is required; in particular, incentive payment systems, methods and standards of inspection, the structure and organization of management, and delegation of responsibility.

The study of individual responses to pressures is as important as the study of the pressures themselves.

The new enthusiasm for industrial sociology has tended to obscure the older studies of individual differences. It may now be time to look at these again in the light of better understanding of the social pressures involved.

Examination of status systems in industry is not new. Nevertheless, there is need to know more about the extent to which the use of the special knowledge and ability of the technician or technologist is hindered by the status systems in industry, particularly the caste system dividing management from technical grades. This is in need of overhaul based on sociological understanding.

The work of Simon and his associates in the United States has shown what can come from a rigorous analysis of some aspects of decision taking. There is a point in each organization at which there is someone who has the necessary authority to take a particular decision. Also located in this organization is someone who has the knowledge for the best decision to be taken. The problem is how to get these two points to coincide: How can effective authority coincide with effective knowledge?

Industrial relations generally means relationship of management to labour. Equally important for the health of any concern is its management/management relations. These may not burst into active conflict, but latent conflict is continuous and may be dangerous. This conflict is neither altogether avoidable nor altogether bad; every time a functional organization is set up a conflict of interest is created. Each functional department tends to seek to maximize what, from the point of view of the organization as a whole, needs to be optimized. For example, a production department will naturally have maximum production as its goal; an inspection department will naturally tend to seek maximum quality or minimum errors. From the point of view of the concern as a whole, a compromise between these conflicting aims has to be achieved. Less obvious but equally profound conflicts of aim will occur between the personnel department and the department of the accountant or financial controller. The problem is not how to resolve this conflict but how best to use it and keep it within bounds.

T. H. Hawkins

TRAINING ENGINEERING GRADUATES

THE graduate aiming at membership of one of the professional engineering institutions normally undergoes a period of practical training or apprenticeship following the completion of his undergraduate course.

Some three years ago the Institution of Electrical Engineers issued a report entitled "The Training of Graduates" in which the purposes of practical training for graduates were outlined and recommendations for the structure of training courses were made. This report, revised and modified, has now been re-issued*.

The general pattern of training recommended does not differ in its essential features from that described in the earlier report. Training should occupy two years and should comprise basic workshop training, general mechanical and electrical training and what is termed directed objective training. It is emphasized that each phase of the training course should be carefully planned and supervised and that the graduate in his practical training should continue to experience something of the intellectual stimulus and of the urge to intensive individual effort which are inherent in academic studies.

Separate sections of the report deal with schemes of training conducted in a works making heavy electrical plant, a factory for light-current equipment and in an operating organization, such as an electricity supply undertaking or a telecommunication service.

While the majority of electrical engineers study, as undergraduates, electrical engineering, a substantial proportion read physics and a few mathematics. The special needs and interests of such graduates in physics and mathematics are met by a scheme of training based on the laboratory but providing for some direct contact with manufacture and development.

There is one important new feature in the recommendations. This is the recognition of training through experience in a staff appointment as an alternative to the traditional form of graduate apprenticeship. This envisages the graduate being engaged as a member of the staff of a professional engineer who will directly supervise his training. The training course will not then conform to any standard pattern, but will comprise the acquiring of experience on a series of projects. These will be so chosen as to provide in the aggregate a range of experience equivalent to that provided by the normal graduate apprenticeship. Great stress is laid on the personal responsibility accepted by the engineer who undertakes to provide this type of training.

* Institution of Electrical Engineers. The Training of Graduates: a Report of the Joint Committee on Practical Training in the Electrical Engineering Industry. Pp. 34. (London: Institution of Electrical Engineers, 1960.) 2s.

POLIOMYELITIS

SINCE the last World Health Organization specialist Committee on Poliomyelitis met in 1957 not only have inactivated poliovirus vaccines come into widespread use but also live attenuated vaccines have been submitted to intensive study and, in some countries, have already been employed on a scale that could scarcely have been envisaged three years ago. These developments and the problems they raise are fully reviewed in the third report of the Committee (Expert Committee on Poliomyelitis, Third Report. World Health Organization: Technical Report Series, 1960, No. 203; 53 pages. Price: 3s. 6d., 0.60 dollars, Sw. Fr. 2. Also available in Spanish and French).

In most countries where inactivated vaccines have been widely used the protection obtained has been of the order expected on the basis of controlled field trials. Manufacturing and testing problems appear to

have diminished with increasing experience, but recent attempts to manufacture polyvalent vaccines containing poliomyelitis antigen have raised some special problems. Experience with such multiple antigens is still too limited for their value to be assessed.

The safety of live poliomyelitis vaccines appears to have been satisfactorily demonstrated in a number of areas where they have been used on a large scale, and, in all except two of these areas, the incidence of poliomyelitis has fallen. It is still too soon, however, to evaluate the long-term effectiveness of live vaccines. Criteria for evaluating the safety and effectiveness of such vaccines are formulated in the report. In this connexion, further research on virus markers and on the degree of viræmia produced by different strains is urgently needed. The capacity of the various strains to spread contacts in the community is also a matter needing investigation. The Committee proposed criteria for the selection of suitable strains and for grading various strains of the three sets of vaccines in use. It also gave attention to the possible contamination of live poliovirus vaccines by simian viruses, and recommended the study of their pathogenicity and methods of differential inactivation.

The choice of inactivated or live virus vaccine for large-scale immunization programmes will depend on the epidemiological, social and economic circumstances of the country concerned. The Committee examined the advantages and disadvantages of the two types of vaccine from these aspects and suggested a number of considerations to be kept in mind by public health authorities when deciding which policy to adopt. Emphasis is laid on the importance of serological surveys and surveillance for the efficient conduct of immunization programmes. Finally, attention is directed to the increasing prevalence of other enterovirus infections (Coxsackie and ECHO viruses) which cause a wide range of clinical manifestations sometimes resembling poliomyelitis. Continued research is needed in this field, especially to detect any increase in the severity of the clinical manifestations in special groups, for example, new-born infants.

UPPER WINDS OVER THE WORLD

THE appearance of *Geophysical Memoir* No. 103 from the Meteorological Office will be welcomed by all who use upper-wind data, whether for geophysical or aviation purposes*. This supersedes *Geophysical Memoir* No. 85, which had the same title, and was published ten years ago, but has long been out of print. The present publication is based, almost entirely, on data for the five-year period 1949–53. Though the International Geophysical Year will have provided a wider coverage to greater heights, it will always be useful to have a detailed analysis of the epoch 1949–53 for reference and comparison, particularly as the information is given for the months of January, April, July and October, rather than as averages for the three-monthly periods of four seasons. This latter procedure was adopted in *Geophysical Memoir* No. 85 on account of paucity of data, but results in excessive smoothing. Average contours are given at the pressure-levels 700, 500, 300, 200, 150 and 100 mb. (approximately 3,000–16,000 m.) and also the average winds are given by diagrams of streamlines and isotachs. The North Polar regions have circumpolar charts for the regions north of 65° N., but no data for the southern hemisphere are given south of 65° S. This is because of the absence of data, for there are large areas of the southern oceans without observations and there must have been a great deal of guess-work there.

Meteorologists will be especially interested in the vertical cross-sections of average zonal wind and potential temperature given for the longitudes 140° E., 75° E., 10° W., 75° W., 130° W. and 180° W. for the same months. These illustrate very dramatically the complexities of atmospheric motions.

In order to estimate the probable wind at any point, it is also necessary to know the standard vector deviation, as well as the average wind. Charts of standard deviation are not provided, but it is promised that they will be given in a later publication.

A. W. BREWER

* Air Ministry: Meteorological Office. *Geophysical Memoirs*, No. 103: Upper Winds over the World, Parts 1 and 2. By H. Heastie and P. M. Stephenson. Pp. i+217. (M.O. 631c.) (London: H.M. Stationery Office, 1960.) 30*s.* net.

DIRECTION OF THE GEOMAGNETIC FIELD DURING THE TRIASSIC PERIOD IN SIBERIA

By DR. E. R. DEUTSCH
Imperial Oil Research Laboratory, Calgary, Alberta
AND
N. D. WATKINS
Shell Oil Co. of Canada, Edmonton, Alberta

AN earlier detailed study of the Deccan Trap formation[1,2] revealed, wherever samples were taken, the existence of a stable remanent magnetization making large angles with the ambient field. One explanation has been that India was in middle latitudes of the southern hemisphere during the late Cretaceous or early Eocene. This would also conform broadly to palæogeographical reconstructions offered in the literature, according to which India once formed part of a southern super continent the constituents of which later dispersed.

Such an interpretation prompts the question to what extent the rest of what is now Asia participated in the hypothetical northward drift of India. It

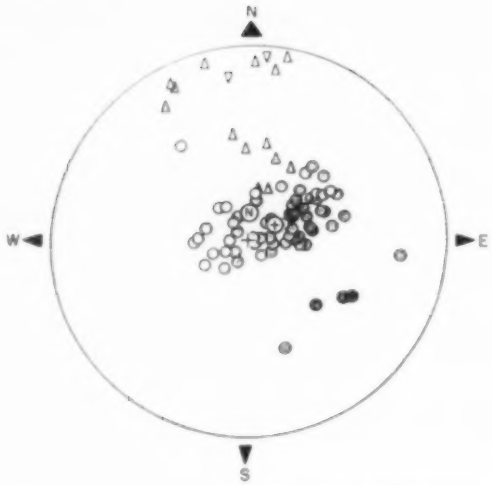


Fig. 1. Polar equal-area plot of the remanent magnetization. △, data for specimens from site *C*, *N*, pole pointing down; ▽, site *C*, *N*, pole up; ○ all other sites, *N*, pole down; ⊕, mean direction for all samples, omitting site *C*; *N* in circle, theoretical dipole field at the sampling locality

seemed that a promising source of evidence might reside in the palæomagnetism of rock formations north of the Himalayas; in particular, the vast Siberian land mass offers manifold opportunities.

Consequently, in 1957, a request for some oriented samples from Siberia was made to Prof. V. V. Fedinsky of Moscow, then attending the eleventh Assembly of the International Union of Geodesy and Geophysics in Toronto. This was arranged without delay, and in 1958 the University of Alberta in Edmonton received a collection of trap rock from the northern part of the Enisei River system.

The samples are from five exposures in the valleys or basins of the Lower Tunguska, Severnaya and Dudinka Rivers, located as follows (Fig. 2): Site *A*, 66·0° N., 89·0° E.; Site *B*, 69·3° N., 88·0° E.; Site *C*, 66·5° N., 90·1° E.; Site *D*, 66·1° N., 89·0° E.; Site *E*, 66·5° N., 89·1° E. The formations are of Lower Triassic age, range in type from gabbro-diabase to diabase, and at all sites are steeply inclined to the horizontal. Gabbro and gabbro-diabase are elsewhere[2] described as typical of the thick intrusive bodies which characterize the Siberian Traps in this region.

Samples were cut into 1–3 cylindrical disks, which will be referred to as 'specimens'. Direction and intensity of their magnetization were determined with a simple astatic magnetometer, mounted inside a hut belonging to the University of Alberta in Calgary, where we carried out the measurements during summer, 1960.

The stereogram (Fig. 1) shows results for all 83 specimens cut from 32 samples. With few exceptions, the vector extremities of the disks from sites *A*, *B*, *D* and *E* form part of a fairly dense central cluster. In contrast, the plot of points from site *C* is anomalous, and

Table 1. Mean Remanent Magnetization of Samples from Sites *A*, *B*, *D* and *E*

S	*N*	Declination	Dip	α_{50}	α_{95}	Intensity (c.g.s.)
67	26	N. 62° E.	+ 76° down	4·0°	8·5°	$(1{\cdot}87 \pm 1{\cdot}14) \times 10^{-3}$

S, number of specimens measured; *N*, number of samples; α_{50}, α_{95}, radii of 50 and 95 per cent circles of confidence, using Fisher's method. All averages are based on samples (*N*), not specimens.

as their scatter exceeds that for any other site, the results were considered unreliable, and hence rejected. The resultant of 26 normalized vectors, all being specimen averages, then corresponds to a west-south-west—east-north-east axis dipping downward steeply towards the east (Fig. 1, Table 1).

In assessing whether this is a true record of the local field direction during Triassic times we make the usual assumption, which seems well supported by theory and some observation, that over periods of 500-1000 years the geomagnetic axis is that of a dipole coaxial with the spin axis. The magnetization of some specimens from each site had been provisionally determined in 1958, but was essentially the same after two years random storage. However, long-term stability may be inferred more compellingly from the data themselves, whenever the vectors form a compact group the mean direction of which is in misalignment with the present local, or dipole, field. The observed angle of deviation, though not large, was taken as significant, for it exceeds the semi-angle of the 95 per cent cone of confidence surrounding the mean vector. Because samples were used in the Fisher analysis, this cone is larger, but probably more indicative of the true scatter at the sampling locality than if all specimens had been weighted equally.

The direction of magnetization furnishes a Triassic north pole in eastern Siberia (Fig. 2, No. 1), as follows:

$$\text{Lat.} = 65^\circ\ \text{N.};\ \text{Long.} = 156^\circ\ \text{E.};\ \delta m = 15\tfrac{1}{2}^\circ;\ \delta p = 14\tfrac{1}{2}^\circ,$$

with δm, δp, semi-axes of the 95 per cent confidence ellipse. Since our investigation began, results of work in the same general area have been published[3] (pole 2);

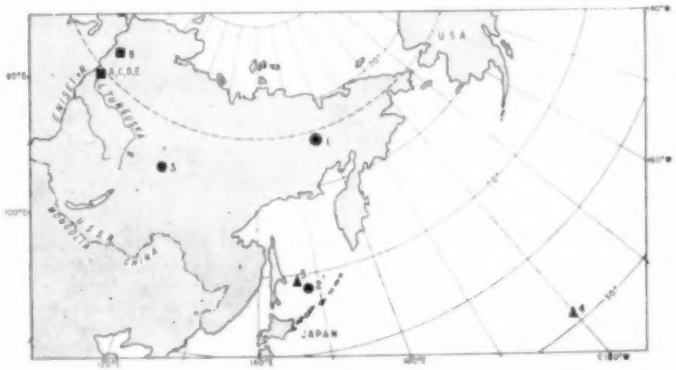


Fig. 2. Location of the north pole with respect to Siberia and Europe, from palæomagnetic measurements on Triassic rocks. Numbers refer to results quoted in this article (1), and by Makarova (ref. 3) (2), Fineberg and Dashkevich (ref. 4) (3), Khramov (ref. 5) (4), and Nairn (ref. 6) (5). Sampling sites are represented by letters

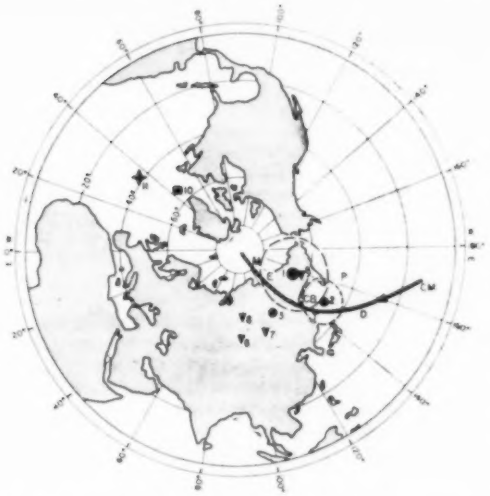


Fig. 3. Location of the North Pole, estimated from palæomagnetic measurements on Triassic rocks. Symbols represent polar plots with respect to: ●, Siberia; ▼, N. America; ■, Africa; ✦, Australia. Numbers indicate source material: 1, our results; 2, 3, other work on Siberian traps (refs. 3, 4); 6, Connecticut lavas (ref. 7); 7, Springdale Sandstone (ref. 8); 8, Brunswickian sediments (ref. 7); 9, New Oxford sediments (ref. 9); 10, Bechuanaland Cave sandstone (ref. 10); 11, Brisbane tuff (ref. 11). The solid line is a polar path relative to Europe, typical of versions published by various authors: *CM*, Cambrian; *D*, Devonian; *CB*, Carboniferous; *P*, Permian; *T*, Triassic; *E*, Eocene; *M*, Miocene

a report[3] on the magnetization of trap rock from the Angara River basin is the source for pole 3.

Palæomagnetic information unlocked from Triassic sedimentary exposures in Europe has yielded pole 4 relative to Russia[5], and pole 5, which is an average quoted by Nairn[6], of British, German and French data by different authors. Our pole, though located rather far north, conforms within limits of error to some point on the smoothed 'European' pole track (Fig. 3). This is not surprising, for it seems likely that in executing any movements inferred from this curve, Europe and northern Asia would have acted as one unit; hence, barring major changes in the Earth's radius, any two contemporary poles from Europe and Siberia should coincide.

Our result differs from three of four pole positions relating to North America[7–9] and, more drastically, from the African[10] and Australian[11] poles. Comparison of global non-Triassic data has revealed many similar discrepancies: the separation of the European and Indian curves exceeds 90° in the Jurassic, the earliest period for which Indian data exist[12]. One can interpret this by invoking large relative displacements between the two land masses, and probably by implication, between India and northern Asia. However, a direct comparison with the Siberian results must await examination of suitable Triassic exposures in India.

We are indebted to Prof. V. V. Fedinsky of the Physics of the Earth Institute, Moscow, and Dr. N. I. Marochkin, director of the Union Geological Research Institute, Leningrad, for making available the rock collection on which this work depended. At the University of Alberta, particular thanks are due to Dr. G. D. Garland, professor of geophysics, for providing workshop facilities and instrumentation, and for his continued interest.

[1] Clegg, J. A., Deutsch, E. R., and Griffiths, D. H., *Phil. Mag.*, Ser. 8, **1**, 419 (1956).
[2] Deutsch, E. R., Radakrishnamurty, C., and Sahasrabudhe, P. W., *Ann. de Geophys.*, **15**, 39 (1959).
[3] Makarova, Z. V., *Bull. Acad. Sci. USSR., Geophys. Ser.* 1959, 1520. Trans. Amer. Geophys. Un., 1081 (1960).
[4] Fineberg, F. S., and Dashkevich, N. N., Report, Third Palæomagnetic Conference, University of Leningrad (Oct. 1959).
[5] Khramov, A. N., "The Palæomagnetic Correlation of Sedimentary Strata" (Gostoptekhizdat, Moscow, 1958).
[6] Nairn, A. E. M., *J. Geol.*, **68**, 285 (1960).
[7] Du Bois, P. M., Irving, E., Opdyke, N. D., Runcorn, S. K., and Banks, M. R., *Nature*, **180**, 1186 (1957).
[8] Runcorn, S. K., *Bull. Geol. Soc. Amer.*, **67**, 301 (1956).
[9] Graham, J. W., *J. Geophys. Res.*, **60**, 329 (1955).
[10] Nairn, A. E. M., *Phil. Mag.* Supp. **6**, 162 (1957).
[11] Irving, E., and Green, R., *Geophys. J. Roy. Astro. Soc.*, **1**, 64 (1958).
[12] Clegg, J. A., Radakrishnamurty, C., and Sahasrabudhe, P. W., *Nature*, **181**, 830 (1958).

GEOLOGICAL RECONNAISSANCE IN VICTORIA LAND, ANTARCTICA

By B. C. McKELVEY* and P. N. WEBB†
Victoria University of Wellington, New Zealand

IN the summers of 1957–58, 1958–59 and 1959–60, three small expeditions from the Victoria University of Wellington investigated approximately 2,500 sq. m. of ice-free terrain west of McMurdo Sound in southern Victoria Land, Antarctica. The first two expeditions spent a total of 80 days in the field, carrying out topographic surveying, meteorological[1] and gravity studies[2], palæomagnetic sampling[3], zoological and botanical studies, and geological surveys. This article summarizes the results of geological surveys made during the first two expeditions and cites references to papers awaiting publication.

* Present address: Department of Geology, University of New England, Armidale, New South Wales.
† Present address: N.Z. Geological Survey, Lower Hutt, New Zealand.

Physiography

The inland ice plateau of eastern Antarctica is bounded at approximately longitude 160° E. by a coastal mountain chain extending 1,000 miles from latitude 70° S. to 85° S. North of latitude 80° S., this mountain chain lies within Victoria Land. Nearly all Victoria Land is completely glacierized; major outlet glaciers flow from the inland ice plateau through the coastal mountain chain to the Ross Sea.

The deglacierized terrain investigated comprises about 2,500 sq. miles of lowland valleys and mountain-

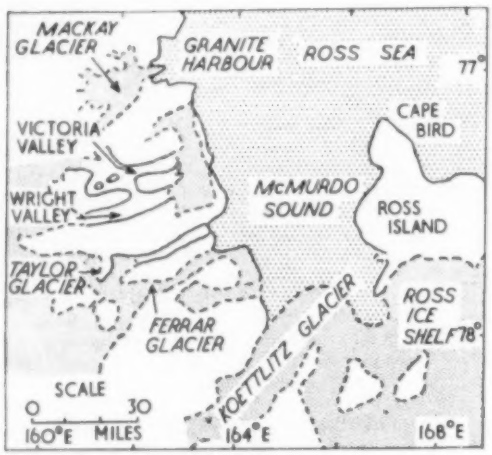


Fig. 1. Locality map of McMurdo Sound region

ous divides lying between the Mackay Glacier (77° S.) and the Taylor and Ferrar Glaciers (77° 45′ S.) (Fig. 1). The Wright Valley and the Victoria Valley system were formerly occupied by glaciers flowing eastwards from the inland ice plateau to McMurdo Sound.

General Geology

In this area, a peneplained Precambrian or lower Palæozoic crystalline basement complex is unconformably overlain by more than 4,000 ft. of Beacon Group sediments (Table 1). Sills and dykes of tholeiitic dolerite intrude both basement complex and Beacon sediments[4].

The Basement Complex. The basement complex exposed in the Wright Valley and Victoria Valley system comprises more than 15,000 ft. of highly folded Precambrian marbles, hornfelses and schists, intruded by acid orthogneiss and coarse porphyritic biotite-hornblende granite. The acid orthogneiss occurs in belts separating the meta-sediments from the biotite-hornblende granite. The meta-sediments strike approximately north to north-west. The foliation of the orthogneiss and porphyritic biotite-hornblende granite also trends north to north-west, parallel to the strike of the meta-sediments. Numerous intrusions of pegmatite and granodiorite dykes with no regular orientation cut through the orthogneiss and the porphyritic biotite-hornblende granite. In the eastern Wright Valley, a swarm of microdiorite dykes dipping south-west intrudes orthogneiss near its contact with the meta-sediments.

An extensive body of homogeneous biotite-hornblende granite ('pink granite' of early workers) intrudes and in many localities overlies the meta-sediments, gneisses and porphyritic granites. Exposures of hornblende-plagioclase amphibolite up to 500 ft. across occur within this younger granite.

Dense swarms of north-east striking lamprophyre and porphyry dykes intrude all basement rocks and in this region are the youngest intrusives of the basement complex.

Beacon Group Sediments. More than 4,000 ft. of Beacon Group (Mid-Palæozoic to Mid-Mesozoic in age) sediments are exposed in the western part of the Taylor and Wright Valleys and the Victoria Valley system, resting unconformably on the peneplained basement surface[5].

These sediments were examined in detail throughout an area of 800 sq. miles, and are subdivided into five lithofacies. From the base of the group the upward succession is:

(1) Sub-greywacke facies: up to 300 ft. of dark, well-indurated conglomerates, sandstones and siltstones. Bedding structures include thin graded beds, cross-beds, and small-scale slump structures.

(2) Arkose facies: at least 500 ft. thick and overlying the sub-greywacke facies, or more commonly resting on the peneplained surface of the basement complex. Bedding structures include small-scale cross-bedding and thick sequences of black, green, red and white beds repeated rhythmically. Ferruginous concretions are abundant in this facies.

(3) Orthoquartzite facies: at least 2,500 ft. thick and characterized by both massive and large-scale cross-bedded units, with thin interbedded lenses of arkose, subarkose and siltstone.

(4) Red-green siltstone facies: varying between 70 and 300 ft. in thickness and observed only on the southern side of Taylor Glacier, where it overlies the orthoquartzite facies. The sediments comprise thin alternating red and green siltstone units interbedded with beds of arkose and orthoquartzite. Mud-crack horizons and concentrations of worm borings are common in this facies.

(5) Carbonaceous shale facies: at least 500 ft. thick and comprising thin, impure coal seams alternating with cross-bedded and slumped sandstones and siltstones. This facies is well exposed near Pyramid Mountain on the southern side of Taylor Glacier, these rocks being the youngest Beacon Group sediments examined during this investigation.

Ferrar Dolerites. The Ferrar Dolerite sills examined have a total thickness of at least 3,000 ft., distributed through a vertical range of 7,000 ft. (ref. 6).

The lowest sill observed is an undulating sheet up to 800 ft. thick, usually intruded into the granites of the basement complex. However, where this sill encounters steeply dipping meta-sediments, it rises along the bedding planes to the peneplained basement surface and intrudes diagonally up into Beacon Group sediments, thinning markedly as it does so.

A younger sill, approximately 700 ft. thick, has penetrated the unconformity between the basement

Table 1. Generalized Geological History for Wright Valley–Victoria Valley System, Victoria Land

Age	Description
Quaternary	At least four phases of glacial cutting and deposition of moraine.
Quaternary to ? Upper Tertiary	Eruption of kenyte, basalt, phonolite and trachyte lavas around McMurdo Sound. Small basaltic cones formed in Taylor Dry Valley, but not in Wright and Victoria Valleys.
? Mesozoic	Intrusion of Ferrar dolerite sills and dykes into the basement complex and overlying Beacon Group sediments.
Mid-Mesozoic to Mid-Palæozoic	Deposition of Beacon Group sediments, including sub-greywacke, arkose orthoquartzite, siltstone and carbonaceous shale facies.
	Major unconformity, with peneplanation.
Lower Palæozoic to Precambrian	Tightly folded, (?) Precambrian marbles, hornfelses and schists intruded by acid orthogneiss and younger granite, granodiorite and diorite. Profuse intrusions of younger acid and basic dyke swarms.

rocks and the overlying Beacon sediments, and in some places intrudes up to 500 ft. above the peneplain surface. Rarely it intrudes granites below the peneplain surface.

Few of the sills intruding Beacon sediments exceed 400 ft. in thickness. Their pattern of emplacement is extremely irregular and they frequently divide into thinner units. Large feeder dykes have been observed to rise to these sills.

The lowest two sills are mineralogically similar and display marked variation. In their lower levels they are composed essentially of hypersthene, augite and calcic plagioclase, whereas their upper levels consist of augite, pigeonite, less calcic plagioclase, and considerable amounts of micrographically intergrown quartz and alkali feldspar. Autoliths of pyroxene aggregations, up to 2 ft. in diameter, and feldspathic veins occur in the lower levels. The upper levels are characterized by pegmatitic veins and schlieren, and show considerable deuteric alteration.

The sills which intrude Beacon Group sediments are relatively homogeneous, consisting of augite, calcic plagioclase and abundant cryptocrystalline mesostasis.

Quaternary Glaciation. Evidence of four glaciations is recognized in the Wright Valley and Victoria Valleys system[7]. The first two were the most intense. Both carried ice from the inland plateau to McMurdo Sound and the Ross Sea. Highly weathered moraines of the first glaciation lie on glacial benches at heights of 4,500 ft. above sea-level. The second glaciation is represented by a thin veneer of highly weathered moraine on the floors of the present valleys and bench remnants up to 2,000 ft. above sea-level.

Thick moraines of a third glaciation partly overlie the second glaciation moraines, indicating a less-extensive advance into the valleys by plateau, alpine and coastal piedmont glaciers. Associated with the moraines of the third glaciation are salt lakes, evaporite deposits, high-level lake shorelines, dune sands and extensive areas of desert pavement strewn with ventifacts.

The limited distribution of thick coarse moraines in the western part of this area indicates that during a fourth glaciation the remnants of the valley glaciers fed from the plateau advanced only short distances eastwards towards the ice-free central portion of the valleys.

Each glaciation resulted from a build-up in the surface elevation of the plateau, allowing ice to spill over high rock thresholds at the valley heads. With each succeeding glaciation, net increases in elevation of the plateau diminished, until during the third and fourth glaciations it was sufficient to allow only a small volume of ice to flow into the valleys.

Since the fourth glaciation, the volume of ice flowing over the valley-head threshold has been negligible. Plateau, alpine and piedmont glaciers are in the final stages of recession from this area.

[1] Bull, C., *Rep. to N.Z. Met. Office* (1959).
[2] Bull, C., *N.Z. J. Geol. Geophys.*, **4** (1960).
[3] Bull, C., and Irving, E., *Nature*, **185**, 834 (1960); *Geophys. J.*, **3**, 211 (1960).
[4] Webb, P. N., and McKelvey, B. C., *N.Z. J. Geol. Geophys.*, **2**, 120 (1959). McKelvey, B. C., and Webb, P. N., *ibid.*, **2**, 718 (1959); and in the press.
[5] Webb, P. N., *N.Z. J. Geol. Geophys.* (in the press).
[6] McKelvey, B. C., *N.Z. J. Geol. Geophys.* (in the press).
[7] Bull, C., McKelvey, B. C., and Webb, P. N., *J. Glaciology* (in the press).

SPECTRAL CHARACTERISTICS OF AGGREGATED CHLOROPHYLL AND ITS POSSIBLE ROLE IN PHOTOSYNTHESIS

By SEYMOUR STEVEN BRODY

International Business Machine Research Laboratory, San Jose, California

AND

MARCIA BRODY

Chemistry Department, Brandeis University, Waltham, Massachusetts

IN 1951 Duysens[1] and French and Young[2] reported the fluorescence (720 mμ) of an unknown pigment in the red alga *Porphyridium cruentum*. The fluorescence was attributed to chlorophyll *d* (ref. 1), which had been discovered by Strain[3] in other algae of this group. Because it absorbed at longer wave-lengths than chlorophyll *a*, and because of the highly efficient transfer of energy to it, Duysens assigned to this pigment the role of an energy trap to explain the low yield of chlorophyll-sensitized photosynthesis—especially on the long wave-length side of the red chlorophyll band. However, it was later determined that there is no chlorophyll *d* present in *Porphyridium*[4].

Recently[5], an emission band at 720 mμ was reported for chlorophyll *a*, both *in vitro* and *in vivo*, and was attributed to an aggregated form of chlorophyll. The present investigation shows that the aggregate is a dimer.

The absorption spectrum of the dimeric form of chlorophyll in ethanol was determined (at 293° K.) from the difference in absorption between dilute (10^{-5} *M*) and concentrated ($>10^{-3}$ *M*) solutions of chlorophyll.

Production of the aggregate is accompanied by a symmetrical splitting of monomer bands which is characteristic[6] of dimer formation. The first excited state of the monomer, 665 mμ, gives rise to absorption maxima at 682 and 648 mμ, with absorption coefficients ε_2 and ε_1, respectively (Fig. 1). One would also expect splitting of the second excited state; however, only one absorption band, at 450 mμ, was resolved. The minor absorption bands also appear to split. From its spectroscopic properties, it was deduced that the dimer has the geometry shown in Fig. 2. By using the relationship $\frac{\varepsilon_1}{\varepsilon_2} = \tan\left(\frac{\pi - \theta}{2}\right)$, the angle θ was found to be 130°.

The source of the asymmetry of the long wave-length band (683 mμ) in Fig. 1 may be a metastable

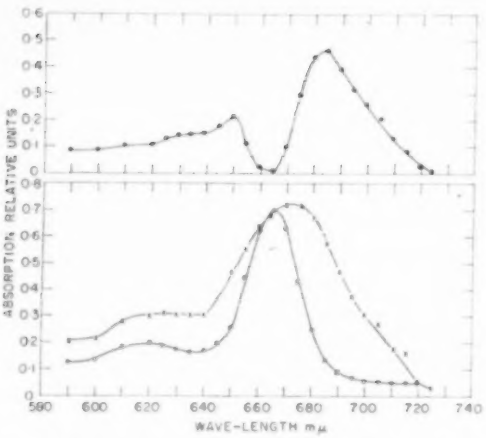


Fig. 1. The curves in the lower graph show the absorption of 10^{-5} *M* (—o—o—) and 3×10^{-5} *M* (—x—x—) solutions of chlorophyll *a* in ethanol. The difference in absorption between these two curves is plotted in the upper graph. This difference spectrum, with maxima at 682 and 648 mμ, is considered to be the absorption spectrum of the dimeric form of chlorophyll at long wave-lengths

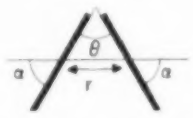


Fig. 2. Geometry of the dimeric form of chlorophyll *a*. Heavy lines depict the planes of the molecules; the angle $\theta \simeq 130°$, and *r* (the distance between the centres of charge density) $\simeq 12$ Å.

transition, with absorption maximum at about 705 mμ. Emission from the dimer, at 720 mμ, may originate from this state.

The equilibrium constant for the reaction $2\,\mathrm{Chl}_M \rightleftharpoons \mathrm{Chl}_D$, in ethanol, was found to be approximately 30 mole^{-1}, where Chl_M and Chl_D are monomeric and dimeric chlorophyll molecules, respectively. Observations of the concentration of the monomeric form in the temperature-range 293°–77° K. show that the equilibrium between these two forms is almost independent of temperature. On the basis of the precision of the measurements, the heat of the reaction, ΔH, is estimated to be less than 20 cal./mole. It was assumed that there are two pathways not dependent on temperature and one pathway dependent on temperature by which the excitation energy of the dimer may be dissipated. The pathways independent of temperature are emission and internal conversion; the pathway dependent on temperature is collisional deactivation (*in vivo*, energy-storing chemical reactions will predominate over collisional losses). The rate constant, k_2, for the deactivation pathway dependent on temperature was equated to $A = \exp(-\Delta E/RT)$. In this expression, ΔE is the activation energy and A is the Arrhenius constant. Values of ΔE and A were determined in the following manner. An expression was derived for yield of emission φ from the dimer as a function of temperature:

$$\ln\left(\frac{1}{\varphi} - \frac{1}{\varphi 77^\circ\,\mathrm{K.}}\right) + \ln\frac{k_1}{A} = \frac{-\Delta E}{RT}$$

where $\varphi 77^\circ$ K. is the yield of emission at 77° K. (found to be 0·8 *in vitro* and 0·1 *in vivo*) and k_1, the reciprocal of the emission life-time, is the rate-constant for the emission process ($k_1 = 1/10^{-8}$ sec.). A plot of the above equation gave: $\Delta E = 1{\cdot}0$ k.cal./mole *in vivo* and 0·9 k.cal./mole *in vitro*, and $A \approx 10^9$ sec.$^{-1}$.

This value of A for the dimer is considerably lower than is usually found for uni- or bi-molecular reactions, and may be considered a measure of the *low* transition probability from the excited triplet state to the singlet ground-state.

A relationship was derived between the ratio of dimer to monomer emission (at 77° K.) and the total concentration of chlorophyll. This expression was in good agreement with the experimental results. Included in the derivation is the assumption that a dimeric form of chlorophyll gives rise to emission at 720 mμ. This mathematical relationship was plotted in graphical form, from which it was possible to estimate the concentration of monomer and dimer in *Porphyridium*, *Chlorella*, *Polyedriella* and *Muriella* to be: 3·2 and 2·0, 1·9 and 0·8, 1·6 and 0·6, and 1·0 and $0{\cdot}2 \times 10^{-3}$ *M*, respectively. These organisms are arranged in order of decreasing dimer/monomer concentration; it is significant that the wave-number at which the photosynthetic decline occurs decreases along the series.

Since a number of emission measurements were made at low temperatures, it was thought necessary to determine the effect of freezing the cells to 77° K. and then thawing them.

An electron microscope study of material treated in this manner showed a small amount of shrinkage and formation of vacuoles, but no real evidence of disruption of chloroplasts.

Chlorella cells were frozen to 77° K., thawed, and then examined for the Hill reaction. Their ability to carry out this photochemical step (even if with diminished yield) and the fact that changes in absorption were not noted after freezing and thawing, were taken as indicating that these processes introduce no gross changes in the photosynthetic apparatus, or in concentration or aggregation of pigment. It might be added that snap freezing is a method of preservation of activity of the Hill reaction[7].

The action spectrum for exciting emission from the dimer was measured *in vitro* at 77° K., and *in vivo* in several different photosynthetic organisms, at 77° K. and 293° K. The results are in qualitative agreement with the absorption spectrum of dimer in solution.

Action spectra measurements with *Porphyridium cruentum* were made at 77° K. to determine the contribution of the various pigments to emission by chlorophyll. These indicate that light energy absorbed by phycoerythrin is transferred to both monomer and dimer; however, more is transferred to the monomer. Energy absorbed by phycocyanin or the chlorophyll monomer favours transfer to the dimer.

The difference between the action spectrum for excitation of fluorescence at 685 mμ and that at 720 mμ supports the contention that there is more than one form of chlorophyll *in vivo*. A review of the evidence, both ours and other workers[8–10], favouring the existence of two (or more) forms of chlorophyll *in vivo*, will be given in detailed papers which are in preparation.

The concept of aggregated chlorophyll has been used to interpret concentration quenching in solution[11,12]. Lavorel[11] has suggested that the long wave-length decline in fluorescence and photosyn-

thesis might be explained by the presence of an inactive chlorophyll dimer *in vivo*.

We conceive of the dimer as being required for participation in photosynthesis, and propose as necessary in this process the interaction of two unstable products produced by light, one (UP_M) formed by the monomer, and the other (UP_D) by the dimer, respectively. The first stable product, S, of photosynthesis is formed by the dark reaction between UP_M and UP_D. These steps are summarized by the following reactions:

$$X + \mathrm{Chl}_M^* \rightarrow UP_M + \mathrm{Chl}_M$$
$$Y + \mathrm{Chl}_D^* \rightarrow UP_D + \mathrm{Chl}_D$$
$$UP_M + UP_D \rightarrow S$$

The unstable products may have life-times of the order of a minute and may be identical with the light-induced radicals reported *in vivo* by Commoner *et al.*[13] and Sogo *et al.*[14].

On the basis of the existence of a monomeric and dimeric form of chlorophyll *in vivo*, and the assumptions made above, we will try to give a relatively simple explanation and indicate relationships for a number of the observations in photosynthesis.

It is postulated that some monomer molecules are associated with dimer molecules: direct absorption by these monomer molecules results in energy being transferred to dimer molecules—so that absorption by the monomer leads to formation of both unstable products. However, when the dimer alone is absorbing light, the yield of emission is low and UP_M is not formed. This is the situation that occurs when photosynthesis or fluorescence is sensitized by light absorbed on the long wave-length side of the chlorophyll maximum. Addition of steady or intermittent light of shorter wave-length to that at longer wave-length will permit the reaction sensitized by the monomer to proceed, resulting in full photosynthetic efficiency. As shown above, the onset of the long wave-length decline is related to the concentration of dimer found in various organisms.

Increase in fluorescence yield with light intensity[15] could result from decomposition of the dimer to monomer.

Changes in absorption induced by light[16] may result from shifts of monomer-dimer concentration, or from changes in position of dimer absorption maxima (determined by the angle θ—which, in turn, appears to be effected by such factors as hydrogen ion concentration).

Details of this work will be published elsewhere. We thank Prof. H. Linschitz, of Brandeis University, for his co-operation and provision of apparatus. Part of this work was done at the Air Force Research Center, Bedford, Mass. This work was supported in part by a grant from the National Science Foundation to Brandeis University (grant *G*–6418).

[1] Duysens, L. N. M., *Nature*, **168**, 548 (1951).
[2] French, S., and Young, V. K., "Pigment Spectra" in *Biological Effects of Radiation*, **2** (McGraw-Hill, New York, 1952).
[3] Strain, H. A., "The Pigments of Algae", in *Manual of Phycology*, edit. by Smith, G. M. (Chronica Botanica Co., Waltham, 1951).
[4] Brody, M., thesis, University of Illinois (1958).
[5] Brody, S. S., *Science*, **128**, 838 (1958).
[6] Kasha, M., and McRae, E. G., *J. Chem. Phys.*, **28**, 721 (1958).
[7] Gorham, P., and Clendenning, K., *Canad. J. Research*, **28**, 513 (1950).
[8] Krasnovsky, A. A., and Kosobutskaja, L. M., *C.R. (Doklady) Acad. Sci. U.S.S.R.*, **91**, 343 (1953).
[9] Brown, J. S., and French, C. S., *Plant Physiol.*, **34**, 305 (1959).
[10] Kok, B., *Acta Botanica Neerlandica*, **6**, 316 (1957).
[11] Lavorel, J., *J. Phys. Chem.*, **61**, 1600 (1957).
[12] Forster, T., and Kasper, K., *Z. phys. Chem.*, NF **1**, 275 (1954).
[13] Commoner, B., Heise, J. J., and Townsend, J., *Proc. U.S. Nat. Acad. Sci.*, **42**, 710 (1956).
[14] Sogo, P. B., Pon, N. G., and Calvin, M., *Proc. U.S. Nat. Acad. Sci.*, **43**, 387 (1957).
[15] Franck, J., French, C., and Puck, T., *J. Phys. Chem.*, **45**, 1268 (1941).

POLYMER MONOLAYERS

By J. M. HAMMOND, MONICA H. WILLIAMS and W. G. P. ROBERTSON

Department of Supply, Weapons Research Establishment, Salisbury, South Australia

IN a recent communication[1] Ries, Beredjick and Gabor described the surface behaviour of polyvinyl benzoate, which showed several unusual features, and directed attention to the wide variation of polymer surface properties with molecular structure. We have recently studied monolayers of three sets of polymers of different structural types, and the results further accentuate the complexity of behaviour obtainable with monolayers of vinyl-type polymers.

The first set of polymers was a series of samples of polymethyl acrylate the viscosity-averaged molecular weights of which varied from $2{\cdot}6 \times 10^4$ to $4{\cdot}75 \times 10^6$. The second set of polymers were graft copolymers of *iso*butene and methyl acrylate in which the number and length of polymethyl acrylate (PMA) branches were varied on a fixed poly*iso*butene (PIB) backbone ('Vistanex' *LM/MS*, $\overline{M}_v$ $4{\cdot}5 \times 10^4$). The third set comprised a number of samples of chlorosulphonated PIB ('Vistanex' *LM/MH*, $\overline{M}_v$ $7{\cdot}2 \times 10^4$) with varying chlorine and sulphur contents, and their hydrolysis products in which the sulphonyl chloride groups had been substantially, if not wholly, converted to sulphonic acid groups. The graft copolymers were prepared by an established photochemical bromination-debromination technique[2] and the Reed-Horn reaction[3] was used for the chlorosulphonation of PIB. Film balance measurements were made at 25° C. on dilute acid ($N/100$ hydrochloric acid) and other substrates with benzene used principally as spreading solvent. A few results obtained with acid substrate are given in Table 1 and Fig. 1 which include also, for comparison, the results given by Ries, Beredjick and Gabor[1] for polyvinyl benzoate (PVB), polyvinyl acetate (PVAc) and stearic acid.

PMA was found to behave similarly to PVAc but was rather more compressible. The most interesting feature of the PMA results was the observed significant variation in limiting area (23·0–26·5 Å.^{2}/monomer unit) over the range of molecular weight studied. Previously some workers have claimed limiting area to be independent of molecular weight[4]. Others have

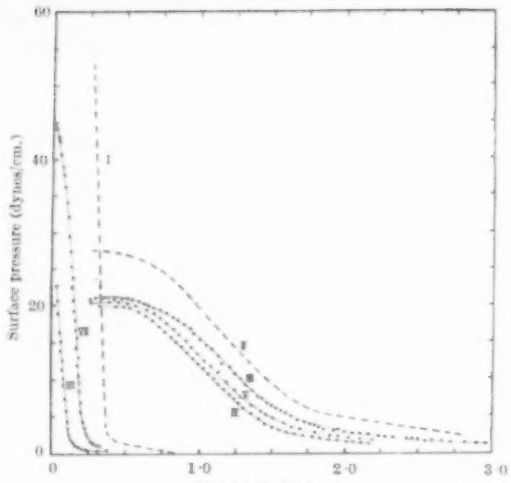


Fig. 1. Pressure-area isotherms. I, isotherm for polyvinyl benzoate (ref. 1); II, isotherm for polyvinyl acetate (ref. 1); III, isotherm for polymethyl acrylate, $\overline{M}_v$ 2·73 × 10⁶; IV, isotherm for polymethyl acrylate, $\overline{M}_v$ 3·2 × 10⁴; V, isotherm for PMA/PIB graft polymer; VI, isotherm for chlorosulphonated PIB; VII, isotherm for hydrolysed chlorosulphonated PIB

found some increase with molecular weight[5] but not as great as that reported here. However, it does seem that we have gone to rather higher molecular weights than most other workers. It is probable that, with flexible molecules, as the molecule-length increases, intermingling of molecules becomes increasingly restricted so that at the higher molecular weights packing on the surface becomes less efficient.

PMA and PVAc monolayers behave rather similarly, and the behaviour of PVB makes an interesting contrast. In the case of PVB the high collapse-pressure is attended by a low limiting area. The preferred explanation[1], in terms of the postulated formation of rigid coils or folds rising from the surface, would also account for the high resistance to compression in the linear region of the isotherm. A further interesting feature of the PVB isotherm is the very low resistance to compression at areas greater than 0·4 m.²/mgm. In this region monomer units are being forced out of the surface to form the rigid overfilm; the feeble resistance to compression in this region indicates that this ejection from the surface is much more easily achieved with PVB than with PMA and PVAc which do not attain such a high collapse-pressure, but which reach their maximum resistance to compression at areas of approximately 1·5 m.²/mgm.

Table 1. Monolayer Properties

	Limiting area		Collapse pressure (dynes/cm.)	Compressibility (cm./dyne)
	m.²/mgm.	Å.²/monomer unit		
Stearic acid*	0·43	20†	42	0·0019
Polyvinyl acetate*	1·90	27	25	0·0252
Polyvinyl benzoate*	0·38	9	53	0·0056
Polymethyl acrylate	1·61–1·86	23·0–26·5	21	0·030
PMA/PIB graft (1·02 : 1 w/w, 2–3 PMA branches per mol.)	1·68	23‡/10·7§	20·4	0·030
CS–PIB (S, 3·3 per cent; Cl, 10 per cent)	0·12	*c.* 1·5	23	0·030
HCS–PIB (S, 2·4 per cent; Cl, 7·8 per cent)	0·23	*c.* 3	44	0·015

* Ref. 1.
† Area per molecule.
‡ Assumed area per PMA monomer unit.
§ Calculated area per PIB unit.

Poly*iso*butene does not spread at all at the air-water interface, neither does brominated PIB at least up to 14·4 per cent bromine content. Mixtures of PMA and PIB were found to behave just the same as if the PIB were not present. This suggests that with the mixture the PIB exists on the surface in a completely collapsed state and its presence in no way affects the behaviour of PMA. It is assumed, therefore, that with the PMA/PIB graft copolymers the behaviour of the PMA branches is not appreciably affected by the presence of the PIB backbone and that the limiting area of the monomer units in the PMA branches is close to that found for homopolymer of similar degree of polymerization, although the two limiting areas may not be identical due to some restriction of the packing of PMA when present as branches. On the basis of this assumption, it was immediately obvious from the results obtained with the graft copolymers that the PMA branches fell short of accounting for the total observed limiting area and that some 11 Å.² must be occupied per *iso*butene unit in the case of the graft copolymer cited in Table 1, which had some two to three branches of PMA ($\overline{P}_v$ 3·21 × 10²) grafted on to the PIB ($\overline{P}_v$ 8·04 × 10²). Models of the *iso*butene unit projected on to a plane surface give areas ranging from 14 Å.² to 22 Å.² for various orientations. While the accuracy of calculating in this way the area occupied by an *iso*butene unit in the graft copolymer is debatable, the value obtained (10·7 Å.²) does indicate a surprisingly large extension of the backbone by a few horizontally orientated polymeric branches. Indeed, the result suggests that the actual number of branches present considerably exceeds the number calculated (2–3) from PMA content and average degree of polymerization. The branch degree of polymerization was assumed to be the same as the $\overline{P}_v$ of a PMA homopolymer prepared under similar conditions of rate, solvent (cyclohexane) and transfer agent (triethylamine). This method of calculating branch frequency overlooks, by its very nature, the possible existence of numerous branches much shorter than the average.

Hydrolysed chlorosulphonated PIB polymers (HCS–PIB) gave high collapse-pressures, up to 44 dynes/cm. The unhydrolysed chlorosulphonated polymers (CS–PIB) gave much lower collapse-pressures and were much less resistant to compression than their hydrolysis products. Calculation of limiting areas for these randomly substituted polymers in terms of Å.² per monomer unit are rather approximate. The values thus obtained are very low and indicate, as one would expect from the relatively infrequent occurrence of polar groups, that these polymers are not horizontally orientated. Areas occupied per polar group were in the range 20–30 Å.², that is, comparable with the limiting area per molecule of stearic acid. It is evident that the hydrocarbon chain forms loops above the surface and this permits fairly close packing of polar groups. In spite of some similarity with stearic acid type behaviour, these polymer films are much more compressible: more compressible in fact than PVB (horizontally orientated, high collapse-pressure) and more akin, in this

respect, to PVAc and PMA (horizontally orientated, low collapse pressure).

Less highly substituted chlorosulphonation derivatives of PIB were, as expected, less surface-active than the examples given in Table 1. More highly substituted derivatives were also less active; this is attributed to partial solubility since with increasing substitution there is an increasing possibility of highly polar groups occurring sufficiently close together to render portions of the molecules soluble in water.

HCS-PIB polymers gave solid films, while the CS-PIB, PMA and graft polymer films were fluid.

A detailed account of this work and further discussion is being prepared for publication.

Acknowledgment is made to the Chief Scientist, Department of Supply, South Australia, for permission to publish this work.

[1] Ries, Jun., H. E., Beredjick, N., and Gabor, J., *Nature*, **186**, 883 (1960).
[2] Jones, M. H., Melville, H. W., and Robertson, W. G. P., *Nature*, **174**, 78 (1954); *La Ricerca Sci.*, **25** (Supp.), 271 (1955). Jones, M. H., *Canad. J. Chem.*, **34**, 948, 1027 (1956).
[3] Reed, C. F., U.S. Patent, 2,046,090 (1936).
[4] Crisp, D. J., *J. Colloid Sci.*, **1**, 49 (1946). Harkins, W. D., Carman, E. F., and Ries, H. E., *J. Chem. Phys.*, **3**, 692 (1935). Moss, S. A., *J. Amer. Chem. Soc.*, **56**, 41 (1934).
[5] Benson, G. C., and McIntosh, R. L., *J. Colloid Sci.*, **3**, 323 (1948). Müller, F. H., *Z. Elektrochem.*, **59**, 312 (1955).

HIGH-YIELD CRYSTALLIZATION OF UREASE FROM JACK BEAN

By Dr. KIYOMICHI HANABUSA

Department of Biochemistry, School of Medicine, Keio University, Tokyo

CRYSTALLIZED urease of jack bean was obtained by Sumner[1] by quite a simple procedure, but very few samples of jack bean are suitable as the starting material for this method. The causes of the difficulties are believed due to: (1) the samples contained a relatively small amount of urease[2] (less than 90 units per gm.); (2) in the case of some samples urease is difficult to extract with 32 per cent acetone, as the first step of method, while containing the usual amount of enzyme[3]. Jack beans cultured in Japan belong to this type[4].

To obtain the preparation of urease crystals from these samples is impossible by Sumner's method. The present investigation was undertaken to find a method of purification of urease which is applicable to such samples.

In an attempt to provide crystallized urease by the application of methods usual for other enzymes it was observed that, as the purification proceeds, urease was apt to be converted so as to be insoluble in water, especially after treatment with acetone. This insoluble form of urease with its activity still preserved has already been studied by Sumner[5]. Because of this, any kind of usual fractionation procedure was not applicable for further purification. This insoluble form was changed into a soluble one by mixing with urea; but after dialysation it was not susceptible to any fractionation, and SH_2 seemed to have little ability to dissolve this insoluble form. Uehara and Kobashi demonstrated that cysteine can convert this insoluble form into the soluble form[6]. I used 2-mercaptoethanol instead of cysteine and devised a method of preparation of crystalline urease with good yield from jack bean, though it contains a low concentration in units of urease.

Jack beans cultured in Japan, *Canavalia ensiformis* var. *gladiata*, were used. They were pulverized into fine powder which contained 100–180 units of urease per gm. The defatting treatment was unnecessary for the present purpose. Acetone was treated with a small amount of potassium permanganate and anhydrous potassium carbonate, then distilled. Calcium phosphate gel was prepared by the method of Tsuboi and Hudson[7].

Both the colorimetric timing method[8] and Iwasaki's azotometry[9] were used for the assay of urease activity under conditions devised by Sumner and Hand[2], and the latter was employed when an accurate value was required. For the determination of protein nitrogen the sample was first digested as usual and the nitrogen of ammonium salt was determined by Iwasaki's azotometry[10]. Protein including urease[11] was calculated by assuming that it contains 16 per cent of nitrogen. The specific activity, that is, units per gm. of protein, was calculated from the foregoing data.

Utilization of several procedures usual in the purification of other enzymes has been studied, of which the following series of procedures was most satisfactory. All work was carried out at room temperature, and distilled water made by a gilded-tin vessel was used throughout the work. 500 gm. of jack bean meal to which 2·5 litres of water had been added and stirred for 10 min. was first filtered through a cloth sack. The residue was again treated with 1·0 litre of water and treated in the same manner, then both filtrates were collected, suspended together with 'Celite' and filtered again through a Büchner funnel. About 3 litres of yellowish brown, slightly turbid, filtrate was obtained.

To 3 litres of filtrate, 1,370 gm. of solid ammonium sulphate was added to give 60 per cent saturation. After a few hours, the resulting precipitate was collected by centrifugation and dissolved in 700 ml. of water. The solution was dialysed against a stream of tap water for about 24 hr., enough time for there to be precipitated the considerable amount of resulting denatured impurities; these were centrifuged off and discarded. Approximately 1,700 ml. of dialysate was obtained.

The dialysate was mixed with 850-ml. portions of calcium phosphate gel. The *p*H of the mixture was adjusted to 5·0–5·5 with 1 *N* acetic acid and allowed to stand for 20 min. with gentle stirring. The gel was collected by centrifugation. It has been shown from experimental results that for each 100 mgm. of protein in the dialysate 50 mgm. of calcium phosphate gel in dry weight was necessary for almost complete

adsorption of urease. Usually 1 ml. of dialysate includes 13–18 mgm. protein, and the same amount of gel includes 14 mgm. of calcium phosphate; accordingly, one might use expediently one volume of gel to two volumes of dialysate for adsorption of the enzyme.

Elution was accomplished by gentle mixing of the gel, avoiding foaming with 200 ml. portion of $M/15$ phosphate buffer, pH 7·5, for 15 min. This is done three times, and the eluates obtained after centrifugation in each case were pooled. Total eluate was approximately 600 ml. and displayed the activity of between 6,000 and 8,000 units per gm.

The eluate was made up to 50 per cent saturation with ammonium sulphate by adding 230 gm. of it and kept for 5 hr. At the end of this time, the precipitate was recovered by relatively high-speed centrifugation, dissolved in 80 ml. of water and the enzyme solution was dialysed against 2 litres of distilled water for 15 hr. (or overnight) in the cold. The outer fluid was renewed three times during the dialysis and about 150 ml. of dialysate was obtained, of which activity was about 12,000 units per gm.

Urease in the dialysate was changed into insoluble form by precipitation with acetone. At first the dialysate was brought to $M/15$ referring to potassium phosphate by addition of either solid potassium dihydrogen phosphate or 0·5 M of its solution. If some amount of precipitate had appeared during the period of dialysis it was usually redissolved by this treatment. (This precipitate contains considerable urease so it should not be discarded.) Urease in solute state was then precipitated by dropwise addition of 0·6 vol. of acetone with continuous stirring. To ensure that the urease is converted completely into insoluble form, the mixture was allowed to stand for 2 hr. at room temperature. Then the precipitate containing the insoluble form of urease was collected by centrifugation and washed with a small portion of water. Usually 93–99 per cent of urease activity in dialysate was recovered in the precipitate by this procedure.

The insoluble urease is made soluble by the action of 2-mercaptoethanol and the majority of the impure protein rejected as the insoluble part, so that the specific activity will increase considerably in this step.

A mixed solution composed of 36 ml. of 0·025 M citrate buffer pH 7·0 and 4·0 ml. of ten times diluted aqueous solution of 2-mercaptoethanol was added to the acetone precipitate, stirred enough to be homogeneous and allowed to stand for 1·5 hr. with intermittent stirring, after which the remaining precipitate was centrifuged off. In this instance, approximately 70 per cent of the activity was transferred to the supernatant, amounting to 40 ml. After this was adjusted to pH 6·0 with 0·1 M citric acid, 0·3 vol. of acetone (12 ml.) was added and kept in an ice chamber at 5° C. Urease was soon crystallized out and the crystallization was completed within a few hours.

The crude crystals generally included a small amount of insoluble impurities. The recrystallization was easily achieved by the method of Dounce[12]. The content of nitrogen, urease units, specific activity and yields at each step in each instance are shown in Table 1, as an example.

Urease was purified some 1,000 fold from starting material with yield 23–33 per cent and crystals were also obtained from material showing a low activity of only 65 units per gm. Attempts to simplify the procedure described here were made, but a satisfactory result was not obtained.

Table 1

	Total N (mgm.)	Total units (×100)	Specific activity (units/gm.)	Yield (per cent)
Starting material	—	680	136	100
Water extract	23,500	630	428	92·5
First ammonium sulphate fractionation	5,290	575	1,740	84·4
Calcium phosphate gel eluate	885	378	6,830	55·5
Second ammonium sulphate fractionation	458	326	11,400	47·9
Precipitate with acetone	378	300	12,700	44·1
Redissolved solution	95·2	236	39,700	34·7
Crude crystal	41·4	221	85,400	32·5
Recrystallization once	29·7	212	114,000	31·2
Recrystallization four times	20·4	166	130,000	24·4

The urease crystals obtained in this way were colourless octahedrals in form of 3–8μ in diameter. A photograph by phase contrast microscope is presented in Fig. 1. The specific activity of pure urease crystals which were recrystallized four times was determined; they had an activity of 130,000 units per gm. The electrophoretic experiments with them were carried out in veronal buffer of ionic strength 0·05, pH 8·6 and in $M/30$ phosphate buffer, pH 7·0, respectively. Only one single and symmetrical peak was observed under these conditions.

Ureases which occur in some kinds of jack beans are with difficulty extracted with aqueous acetone, though these samples include sufficient amounts of urease in them[3,4]. They are unsuitable as starting material for the method by Sumner. However, almost all the urease in any sample is easily extracted with water; because of this the aqueous extract of urease was made in the first step. It is reasonable to assume that some obstructive factors may exist in these samples when aqueous acetone was used for the extraction of urease. Sumner demonstrated previously that purified urease was converted into insoluble form by the procedures consisting in adding ethanol and sodium chloride to its solution and keeping it at room temperature[5]; moreover, even crystalline urease gave the same result[13]. I found that, as the purification of urease

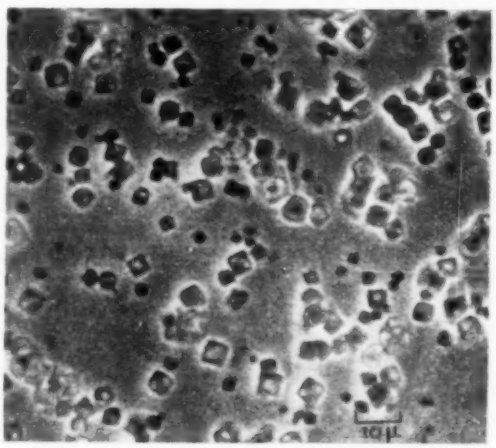


Fig. 1

proceeded, more than 10,000 units per gm. could be easily converted into the insoluble form by addition of acetone. Uehara and Kobashi proved that insoluble urease recovered its solubility by the action of cysteine or glutathione. In the present work, loss of activity was scarcely recognized when urease was converted into insoluble form by treatment with acetone. It recovered its solubility by the action of 2-mercaptoethanol; at the same time a small portion of impure protein was also redissolved out of the insoluble precipitate. This was found as insoluble impurity when urease was recrystallized. From these points of view it is reasonable to infer that among the sulphydryl groups of the urease molecule there must be a special part which is relevant to the formation of the insoluble form as well as indifferent to the revealing of enzyme activity, and the formation of disulphide linkages does not occur only between urease molecules themselves but also between different protein molecules. Urease was crystallized with good yield starting from aqueous extract of jack bean meal; whereas it might be unsuitable for Summer's method. Urease crystals thus obtained were identical with respect to the crystal form and activity to those obtained by Summer's method[11].

I wish to express thanks to Prof. K. Sekita for his kind guidance and constant encouragement throughout this work. Thanks are also due to Dr. K. Kobashi for his helpful suggestions. This work was supported in part by a research grant from the Taito-Pfeizer Co., Ltd.

[1] Sumner, J. B., *J. Biol. Chem.*, **69**, 435 (1926).
[2] Sumner, J. B., and Hand, D. B., *J. Biol. Chem.*, **76**, 149 (1928).
[3] Sumner, J. B., and Holloway, R. G., *J. Biol. Chem.*, **79**, 489 (1928).
[4] Kitagawa, M., and Funatzu, M., *Chem. Abs.*, **36**, 2893 (1942).
[5] Sumner, J. B., and Graham, V. A., *Proc. Soc. Exp. Biol. Med.*, **22**, 504 (1925).
[6] Uehara, K., and Kobashi, K., *J. Jap. Biochem. Soc.*, **31**, 715 (1959).
[7] Tsuboi, K. K., and Hudson, P. B., *Arch. Biochem. Biophys.*, **53**, 341 (1934).
[8] Van Slyke, D. D., and Archibald, M., *J. Biol. Chem.*, **154**, 623 (1944).
[9] Waseda, M., and Nakajima, S., *Juzenkaizasshi*, **42**, 2829 (1937).
[10] Iwasaki, K., Otsuki, S., and Nakajima, S., *Juzenkaizasshi*, **42**, 2132 (1937).
[11] Sumner, J. B., *Ber.*, **63**, 582 (1930).
[12] Dounce, A. L., *J. Biol. Chem.*, **140**, 307 (1941).
[13] Sumner, J. B., *Science*, **108**, 410 (1948).
[14] Sumner, J. B., *The Enzymes*, **1**, Part 2, 876 (Academic Press, Inc., New York, 1951).

INHIBITION OF THE MULTIPLICATION OF INFLUENZA VIRUS BY ANILINE DERIVATIVES OF THE FRANCIS INHIBITOR

By Dr. I. HOLLÓS
State Institute of Hygiene, Budapest

IT is generally accepted that the red-cell receptor concerned in haemagglutination by myxoviruses is an analogue of the receptor substances of cells which are susceptible to infection[1]. Two findings seem to support the active role of the receptor[2] in virus multiplication: (1) its amount is subjected to a cyclic fluctuation during the process of multiplication[3]; (2) both the early and late stages of multiplication are inhibited by the same chemical compounds[4].

To investigate this question, human serum α-inhibitor (Francis inhibitor[5]) was prepared from Cohn's 4·4 fraction as recommended by Hirst[6]. The inhibitor was completely inactivated at room temperature by any of the active influenza virus preparations tested.

The interaction between influenza virus *A*[1] Budapest 4/49 (*Bp*) and α-inhibitor is shown in Fig. 1.4. Equal volumes of virus and α-inhibitor solution were kept at room temperature. At intervals, 1 ml. samples were mixed with 0·2 ml. of a 5 per cent suspension of fowl erythrocytes, kept in an ice-bath for 15 min. and centrifuged. The erythrocyte sediment was taken up in 0·5 ml. phosphate buffer, incubated at 37° C. for 2 hr., and centrifuged. The supernatants were titrated by Takátsy's micromethod[7] for haemagglutinin, to determine the amount of virus recovered from the erythrocytes. There was a sudden drop in the recoverable virus in the early minutes, followed, even if virus had completely disappeared, by a rise nearly up to the initial haemagglutination titre.

The disappearance and reappearance of virus might be explained by a competitive antagonism between α-inhibitor and erythrocyte receptor. At the beginning, α-inhibitor, being in excess, prevents the adsorption of the virus on the erythrocytes, but later, as the virus gradually inactivates the inhibitor, more and more of it will become demonstrable.

According to Wolley's concept[8], a haemagglutination inhibitor is expected to inhibit virus multiplication only if it combines with the virus more firmly than does the cell receptor. Mandel and Racker[9] found such an inhibitor to the *GD*VII virus in the intestinal tract of the mouse.

In attempting to prepare influenza virus inhibitors meeting this requirement, we coupled aniline derivatives by diazonium linkage to a purified preparation of α-inhibitor. Coupling was followed by a second purification consisting of fractionations with alcohol, and dialysis at 4° C. against a *p*H 7·2 buffer solution for 3 days. The purified preparation was stored in a frozen or lyophilized state. Control preparation (No. 17, Table 1) was submitted to all the procedures of coupling (mainly oxidative procedures) except for adding aniline derivative.

Table 1. Relative Inhibitory Activity of Modified α-Inhibitors

Preparation No.	Modifying compound	D_{50} in haemagglutination inhibitor units as tested with 10^4 ID_{50} of			
		PR8	*Bp*	Singapore 1/57 non-avid	Lee
3	*p*-Ethyl-aniline	7·0	0·8	11·6	0·75
8	Diethyl-*p*-phenylene-diamine	7·6	3·2	10·2	3·0
1	*o*-Methyl-aniline	10·2	4·8	5·5	4·0
14	*o*-Azotoluene-diazonium chloride	225	10·0	100	10·0
17	None	204	204	> 204	110

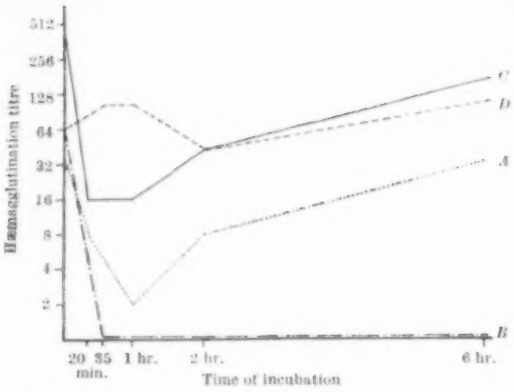


Fig. 1. Influenza virus (strain A[1] Budapest 4/49) recoverable from inhibitor-virus mixtures after incubation for different periods by adsorption to and elution from chicken erythrocytes. Arithmetic means calculated from five experiments

A, 128 *HA* units of virus + 64 *HAI* units of α-inhibitor; *B*, 128 *HA* units of virus + 64 *HAI* units of α-inhibitor, coupled to *p*-phenylenediamine; *C*, 512 *HA* units of virus + 64 *HAI* units of α-inhibitor, coupled to *p*-phenylenediamine; *D*, 128 *HA* units of virus + 3 mgm./ml. *p*-phenylenediamine

HA unit = the amount in 1 ml. of virus suspension causing partial hæmagglutination: *HAI* unit = the amount in 1 ml. which partially inhibited hæmagglutination produced by 1 ml. of Lee virus containing 4 *HA* units

Fig. 1,*B* illustrates an experiment with the *p*-phenylenediamine derivative of α-inhibitor. To prepare this substance, 3 mgm. of the lyophilized α-inhibitor was taken up in 1 ml. buffer solution and coupled to 3 mgm. *p*-phenylenediamine. (The lyophilized material could not be redissolved completely.) When virus was added to this modified inhibitor, a sudden decline in the virus recoverable from erythrocytes occurred. If high-titre viral preparations were used, some rise was observed later (Fig. 1,*C*), but when the virus preparation had an initial titre comparable with those used in the above experiments, no virus could be demonstrated in the eluates during the 6-hr. period of experiment (Fig. 1, *B*). The total disappearance of virus, which has been demonstrated in numerous experiments, could not be attributed to either the α-inhibitor or the uncoupled chemical compound alone (Fig. 1, *A* and *D*).

The inhibition of virus multiplication was examined by Horváth's roller-drum micro-technique[10]. To determine the strength of the inhibitor several dilutions were tested. First, the inhibitor dissolved in 0·5 ml. medium was placed in each vial, then the allantoic membrane fragments in 0·1 ml. were added, and finally 0·1 ml. of the *Bp* strain of virus. The infective titre of the virus alone was also determined as a control. Eight cultures were inoculated with every dilution. After 72-hr. incubation, each culture medium was titrated for hæmagglutination. The inhibition of viral multiplication was expressed as the percentage difference between the arithmetic mean of hæmagglutination titres in the control vials and that for the experimental group. The inhibitory potency of a substance was characterized by the dose which caused a 75 per cent inhibition (D_{75}). In Table 1, D_{75} is expressed in hæmagglutination inhibition units. (One such unit is present in 1 ml. of a preparation which partially inhibits the hæmagglutination of a suspension containing 4 hæmagglutination units Lee virus, in the indicator state, per ml.) In order to estimate the reproducibility of the index D_{75}, that for the diethyl-*p*-phenylenediamine-diazonium-α-inhibitor was determined against 10^4 ID_{50} in five experiments. The coefficient of variation as multiplied by Student's value was found to be ± 55 per cent. In the vials containing too little inhibitor to cause any inhibition the hæmagglutination titres slightly exceeded the control ones. This slight rise in titre was reproducible and found in every experiment. Regardless of this, the relation of inhibitor concentration to the percentage inhibition appeared to be approximately rectilinear and was scarcely influenced by the strength of the inoculum.

According to the D_{75} values determined against three strains (Table 1), preparations Nos. 3, 8 and 1 are considerably more potent (2·75–255-fold) than the control preparation. It was a general observation that different strains were differently inhibited by the same compound. Some preparations, such as No. 14, were even ineffective with one or two strains while definitely effective with others. The inhibition of multiplication by larger doses of the control preparation might be explained by thermo-inactivation occurring while the virus is fixed to the inhibitor.

To obtain some information on the mechanism of inhibition, preparation No. 8 was added to an excess of active virus, kept at room temperature for 48 hr., centrifuged at 20,000 *g* for 1 hr., and the supernatant was heated to 90° C. to inactivate any virus possibly present. The heated supernatant failed to inhibit virus, indicating that the inhibitor had sedimented in combination with virus. (Free inhibitor was not sedimented in control experiments; heating to 90° failed to inactivate inhibitor.)

The inhibitory effect of substance No. 8 has been studied in the embryonated egg. Sixty eggs were infected with 10^5 ID_{50} of the *Bp* strain. Twenty eggs were each given 0·5 ml. of a solution containing 48 hæmagglutination inhibitor units 30 min. before infection, another twenty the same dose 30 min. after infection. The remainder served as control. After 48 hr. incubation the infective titres in the three pools of allantoic fluids were $10^{-7.4}$, $10^{-7.5}$ and $10^{-9.2}$, respectively. A similar inhibition (2·0 $\log_{10}$ units) was demonstrated with the Lee strain as test virus.

Thus it is concluded that some modified preparations of α-inhibitor, being as avid for the influenza virus as α-inhibitor itself, combine with the virus more firmly than α-inhibitor does. Marked reduction in the amount of virus multiplication by preparation No. 8 has been demonstrated in the egg with two strains of virus even if inhibitor was injected 30 min. after infection. The modified inhibitors are expected to help us in studying the role of cell receptor in the multiplication of myxoviruses. Similar derivatives of neuramic acid esters might be of more practical importance.

This work will be published in detail in the *Acta Microbiol. Hung.* (Budapest).

[1] Hirst, G. K., *J. Exp. Med.*, **75**, 49 (1942).
[2] Hirst, G. K., in *Viral and Rickettsial Infections of Man*, ed. by Rivers, T. M., and Horsfall, F. L., 96 (1959).
[3] Schlesinger, R. W., and Karr, H. V., *J. Exp. Med.*, **103**, 333 (1956).
[4] Ackermann, W. W., and Maassab, H. F., *J. Exp. Med.*, **99**, 105 (1954).
[5] Francis, T., *J. Exp. Med.*, **85**, 1 (1947).
[6] Hirst, G. K., *J. Exp. Med.*, **89**, 223 (1949).
[7] Takátsy, Gy., *Acta Microbiol. Hung.*, **3**, 191 (1955).
[8] Wolley, D. W. J., Internat. Symp. *The Dynamics of Virus and Rickettsial Infections*, 421, edit. by Hartmann, F. W., Horsfall, F. L., and Kidd, J. G. (1953).
[9] Mandel, B., and Racker, E. J., *J. Exp. Med.*, **98**, 399 (1953).
[10] Horváth, S., *Acta Microbiol. Hung.*, **1**, 481 (1954).

ACTION OF *VICIA FABA* ON ERYTHROCYTES: POSSIBLE RELATIONSHIP TO FAVISM

By Dr. J. E. BOWMAN and Dr. D. G. WALKER*

Department of Pathology, Shiraz Medical Centre, Nemazee Hospital, Shiraz, and Department of Biochemistry, University of Shiraz, Shiraz, Iran

THE disease favism is a hæmolytic anæmia which results from the ingestion of the broad bean (*Vicia faba*) by some people. The disease has been recognized in most countries around the Mediterranean Sea for many years, and its clinical manifestations have been well documented[1]. Work both in Italy[2] and Israel[3] has shown that the disease only occurs in persons who have an inherited abnormality of the erythrocytes in that there is a deficiency of the enzyme glucose-6-phosphate dehydrogenase. This basic deficiency is reflected in a lowered level of the amount of reduced glutathione in the red blood cells and an instability of the glutathione in the presence of certain substances such as acetylphenylhydrazine, aniline, hydroxylamine, α- and β-naphthol and the anti-malarial drug primaquine[4]. Such agents cause both *in vitro* and *in vivo* breakdown of erythrocytic glutathione, whereas agents such as ascorbic acid and cysteine cause *in vitro* destruction only[5,6].

We recently reported[7] that extracts prepared from fresh beans of *Vicia faba* show a selective effect upon the glutathione of erythrocytes from sensitive subjects, that is, those possessing the genetic abnormality. This work has now been extended to show that the active agent of *Vicia faba* is present also in extracts of pollen and pistils, that the effect on glutathione can be demonstrated simply by incubating whole blood of sensitive subjects with whole beans and that the effect is not due to common reducing agents such as ascorbic acid and cysteine.

Table 1 shows the effect of incubating 1-ml. blood samples from both sensitive and non-sensitive subjects with 0·1 or 0·2 ml. amounts of extracts of pollen and pistils. Blood glutathione-levels were measured before and after incubation[6]. The pollen extracts were prepared by suspending 1 vol. of loose pollen in 10 vol. of saline at 4° C. for 1 hr. followed by centrifugation at 500 r.p.m. for 2 min. Pistil extracts were prepared in a similar manner using 5 vol. of saline. Fresh young beans (approx. 8 mm. in maximum diameter) were used in the whole-bean experiments. In all three cases, the incubations showed a significant *in vitro* effect on blood from sensitive subjects compared with non-sensitive subjects.

This effect cannot be due to cysteine because this would give a colour with the nitroprusside reaction used for estimating glutathione. Control experiments showed that the addition of extracts to blood followed by immediate precipitation of the proteins and glutathione estimation (with no incubation period) has virtually no effect upon the apparent blood glutathione-level. Hence the extracts do not contain significant amounts of cysteine. Further, the effect of the extracts is not due to the action of ascorbic acid. To demonstrate this, an extract of fresh young beans was prepared using $\frac{1}{2}$ vol. of saline by the method previously described[7]. The action of 0·2 ml. of this extract (which contains not more than 3 μgm. of ascorbic acid in the 0·2 ml., an amount far below the concentrations reported to have an *in vitro* effect on erythrocytic glutathione[5]) was compared with the effect of incubating 1 ml. of blood with 2 mgm. of ascorbic acid in 0·2 ml. of saline. With an incubation time of 10 min. only the *Vicia faba* extract had a marked effect upon erythrocytic glutathione (Table 2).

Table 1. Effect of Extracts of Pollen and Pistils and of Whole Beans on Erythrocytic Glutathione

Source of activity	Vol. of extract used (ml.)	Subjects	No. of samples	Glutathione (mgm. per 100 ml. red blood cells) before incubation	Glutathione (mgm. per 100 ml. red blood cells) after incubation	*P* value on basis of '*t*' test
				Mean S.D.	Mean S.D.	
Pollen extract	0·2	Sensitive	10	33·2 ± 5·0	21·3 ± 3·2	0·01
		Non-sensitive	8	55·3 ± 8·3	48·0 ± 6·3	
Pistil extract	0·1	Sensitive	10	36·1 ± 4·8	26·8 ± 4·2	0·001
		Non-sensitive	10	56·5 ± 6·0	52·6 ± 7·0	
Whole bean	—	Sensitive	10	36·2 ± 5·3	28·4 ± 5·0	
		Non-sensitive	10	61·8 ± 8·8	61·9 ± 9·1	

These experiments show, therefore, that *Vicia faba* pollen and pistils, in addition to the bean, itself contain an active principle which has a marked effect on the erythrocytic glutathione of sensitive subjects. The action is not due to ascorbic acid or cysteine so that a specific effect of *Vicia faba* is still indicated. This direct action on the red blood cells *in vitro* suggests a way in which ingestion of the bean or inhalation of the pollen might result in *in vivo* hæmolysis.

It remains to demonstrate that the effects shown in this article are specific for *Vicia faba* and are not given by other vegetables at least to the same extent. Whole fresh peas, incubated as in the whole-bean experiments, showed no effect. Certain other vegetables tried, for example, runner beans, caused massive agglutination of the erythrocytes. When this occurs, false low glutathione-levels are obtained, probably due to lack of complete hæmolysis which is necessary for accurate estimation of the whole

Table 2. Effects of *Vicia faba* Extract and of Ascorbic Acid on Glutathione of Three Different Samples of 'Sensitive' Erythrocytes

Before incubation	After incubation with ascorbic acid	After incubation with *Vicia faba* extract
42*	43	29
34	35	24
44	44	28

* All values are in mgm. glutathione per 100 ml. red blood cells. The incubation time was 10 min.; for details see text.

* Present address: Department of Biochemistry, University of Birmingham, Edgbaston, Birmingham 15.

blood glutathione-level. With *Vicia faba* extracts, we have noted non-specific falls in glutathione if added to non-sensitive blood containing insufficient ACD. In these instances coarse clumps of blood were observed. This effect is abolished with the addition of further anticoagulant. Only those results obtained in the absence of agglutination are therefore valid for the purposes of comparison. In our experience, *Vicia faba* extracts are the only ones so far tested which give a statistically verified selective *in vitro* action on erythrocytic glutathione of sensitive subjects.

Though these results in no way prove that favism is caused by a direct action of an agent in *Vicia faba* on erythrocytes by initiating haemolysis, they strongly suggest that such a possibility should be tested *in vivo*. Such a direct action appears to offer an attractive alternative hypothesis as to how sensitive subjects may develop a haemolytic anaemia following ingestion of the broad bean, although the evidence for allergy in addition to the genetic erythrocytic defect cannot be excluded[8].

We are grateful to the Misses Annerose Oemisch and Iran Haffarian for technical assistance and the Wellcome Trust (London) for financial support to one of us (D.G.W.).

[1] Luisada, A., *Medicine*, **20**, 229 (1941).
[2] Sansone, G., and Segni, G., *Boll. Soc. ital. biol. sper.*, **32**, 456 (1956).
[3] Szeinberg, A., Sheba, C., Hirschorn, N., and Bodony, E., *Blood*, **12**, 602 (1957).
[4] Beutler, E., *Blood*, **14**, 103 (1959).
[5] Szeinberg, A., Adam, A., Ramot, B., Sheba, C., and Myers, E., *Biochim. Biophys. Acta*, **36**, 65 (1959).
[6] Beutler, E., *J. Lab. Clin. Med.*, **49**, 84 (1957).
[7] Walker, D. G., and Bowman, J. E., *Proc. Soc. Exp. Biol. Med.*, **103**, 476 (1960).
[8] Szeinberg, A., and Sheba, C., *Israel Med. J.*, **17**, 158 (1958).

A GENE DETERMINING PRESENCE OR ABSENCE OF ε-N-METHYL-LYSINE IN *SALMONELLA* FLAGELLAR PROTEIN

By Dr. B. A. D. STOCKER and Dr. M. W. McDONOUGH
Guinness–Lister Research Unit, Lister Institute of Preventive Medicine, London, S.W.1
AND
Dr. R. P. AMBLER
Department of Biochemistry, University of Cambridge

ACCORDING to current views on the gene control of protein structure[1], the amino-acid which is to constitute a particular link in the polypeptide chain of a given protein is specified by a group of bases in a corresponding region of the deoxyribonucleic acid (DNA) molecule of a gene which determines the structure of this protein. Only twenty amino-acids, all in the L configuration if optically active, are common constituents of proteins, and it has been suggested that only twenty different base-groups occur in DNA which specify amino-acids. This hypothesis predicates: (*a*) that the presence of an uncommon amino-acid in a protein always results from some cause other than its specification by a group of bases in the DNA of the gene determining the amino-acid sequence of the protein (for example, from conversion of a common amino-acid into an uncommon one after its incorporation in a polypeptide chain); and (*b*) that heritable variation in respect of the presence or absence of an uncommon amino-acid in a particular protein must result from the action of a genetic determinant other than the gene determining the amino-acid sequence of this protein. An experimental test of predicate (*b*) has now been made in respect of the uncommon amino-acid ε-N-methyl-lysine, which Ambler and Rees[2] reported as a constituent of the flagellar protein ('flagellin') of some bacteria of the genus *Salmonella*; in the material they examined lysine and N-methyl-lysine were about equally abundant. We have now found that N-methyl-lysine is absent from some *Salmonella* flagellins; and by genetic analysis, using phage-mediated transduction[3], we have located a gene determining the presence or absence of N-methyl-lysine in flagellar protein.

Flagellins from many *Salmonella* strains of various species (serotypes) were tested for N-methyl-lysine by paper electrophoresis of acid-hydrolysed flagella with results to be reported in detail. In the case of diphasic strains (that is, strains able to produce flagella of either of two distinct antigenic types) flagella were collected from cultures in phase 1 and from cultures in phase 2. In each of the ten diphasic strains tested, the two flagellins obtained were alike in respect of presence or absence of N-methyl-lysine. Seven strains of *S. typhimurium* (phase 1 antigen *i*; phase 2 antigen 1,2,3) were all positive for N-methyl-lysine; four strains of *S. paratyphi B* (antigens *b* and 1,2) were all negative for N-methyl-lysine. But of thirteen strains of *S. derby* (phase 1 antigen *f,g*; no second phase), four were negative for N-methyl-lysine, the rest being positive.

We next tested flagellins from a series of motile derivatives of *SW* 543, a non-flagellated monophasic strain of *S. paratyphi B* with the (latent) phase 1 flagellar antigen *b*. The flagellar protein of a flagellated mutant of this strain lacked N-methyl-lysine, like the flagellins of other strains of *S. paratyphi B* tested. Strain *SW* 543 lacks flagella because of mutation at a *fla* locus close to the locus which regulates the phase 1 flagellar antigen, and motile clones obtained from it by transduction of the *fla* gene from a motile donor strain, are of two sorts: one sort show flagellar antigen *b*, and are attributed to replacement of only the *fla*$^-$ gene of strain *SW* 543 by its wild-type allele from the donor strain; the other sort have the phase 1 flagellar antigen of the donor strain, and are attributed to replacement of both the *fla*$^-$ gene and the linked gene determining the phase 1 flagellar antigen *b* of strain *SW* 543 by their alleles from the donor strain[4]. Of nine motile transductant clones of the latter type, with phase 1 flagellar antigens derived from various donor strains, eight were positive for N-methyl-lysine; the donor

Table 1. Antigenic Constitution and N-Methyl-lysine Character of the Flagella of Recombinants obtained by Transduction of Flagellar Antigen-determinants between Diphasic Flagellated Strains

Strain Description	Clone No.	Phase 1 flagella Antigen	Phase 1 flagella NML	Phase 2 flagella Antigen	Phase 2 flagella NML
S. typhimurium wild-type parent strain	*LT* 2	*i*	+	1,2,3	-
S. abony wild-type parent strain	SW 803	*b*	-	*e,n,x*	+
S. typhimurium given H_1^b from *S. abony*	SW 699	*b*	-	1,2,3	+
S. typhimurium given H_1^b from *S. abony*	SW 7	*b*	-	1,2,3	+
S. typhimurium given $H_2^{e,n,x}$ from *S. abony*	SW 698	*i*	+	*e,n,x*	-
S. abony given H_1^i from *S. typhimurium*	SW 933	*i*	+	*e,n,x*	+
S. abony given $H_2^{1,2,3}$ from *S. typhimurium*	SW 932	*b*	-	1,2,3	-

strain concerned in the case of the exceptional, N-methyl-lysine-negative recombinant was found to be itself negative for N-methyl-lysine. By contrast, ten clones of the first type, that is, with antigen *b*, each obtained by transduction of the *fla*$^+$ gene from a N-methyl-lysine-positive strain, were all negative for N-methyl-lysine. These results indicate that the presence or absence of N-methyl-lysine in the flagellar protein of a strain in phase 1 is controlled either by the gene which determines the antigenic character of this protein or by a closely linked gene.

The phase 1 and phase 2 flagellar antigens of diphasic strains are controlled, respectively, by two series of alleles, at loci termed H_1 and H_2, which in phage-mediated transduction appear unlinked[5]. A series of hybrids obtained by transduction of one or other of these genes between flagellated diphasic strains differing both in N-methyl-lysine character and in their phase 1 and phase 2 flagellar antigens were next examined. Table 1 records the results obtained on testing recombinants of a strain of *S. typhimurium* (positive for N-methyl-lysine; flagellar antigens *i* and 1,2,3) and a strain of *S. abony* (negative for N-methyl-lysine; antigens *b* and *e,n,x*); less extensive experiments on other strains gave similar results. It was found: (i) that the antigenically distinct phase 1 and phase 2 flagellins produced by a diphasic recombinant strain were always alike in respect of the presence or absence of N-methyl-lysine; and (ii) that when the phase 1 flagellar antigen of a strain was altered by transduction, the N-methyl-lysine character of the recombinant was always the same as that of the donor strain from which the phase-1 antigenic determinant (H_1) had been transduced; whereas replacement of the phase 2 determinant (H_2) of a strain by transduction from a strain of opposite character had no effect on the N-methyl-lysine character of the recipient strain.

These results indicated that the presence or absence of N-methyl-lysine in the flagellin(s) of a *Salmonella* strain is decided by a genetic determinant which is either closely linked to, or part of, the H_1 locus. To decide between these alternatives, a search was made for re-assortment of phase 1 antigenic character and N-methyl-lysine character during transduction. The recipient strain was a monophasic flagellate strain of *S. paratyphi B* (phase 1 antigen *b*, no second phase) and negative for N-methyl-lysine. Two donor strains were used: in cross 1, a sub-line of *S. typhimurium* strain *LT*2, positive for N-methyl-lysine, diphasic, the phase 1 antigen being *i M6* (a mutant derivative of *i*; Joys, T. M., unpublished work); in cross 2, a non-motile mutant of the *i M6* strain, lacking flagella because of mutation at a site closely linked to H_1. Motile transductants with the phase 1 flagellar antigen of the donor strain were selected by inoculating the phage-treated recipient bacteria into semi-solid medium containing sufficient anti-*b* serum to prevent the spread of motile bacteria with antigen *b*. From cross 1 we tested sixteen clones with antigen *i M6*, resulting from transduction of the H_1 locus from the motile donor strain; all were positive for N-methyl-lysine, like the donor strain. From cross 2 we tested ten clones with antigen *i M6*, resulting from incorporation by recipient bacteria of the H_1 gene from the non-motile donor but not the closely linked *fla*$^-$ gene causing its non-motility; eight were positive for N-methyl-lysine, like the donor, while two were negative, like the recipient. This indicates the existence of a locus for N-methyl-lysine character which is closely linked to H_1, but separable from it, probably lying between H_1 and the gene causing absence of flagella in the non-motile donor strain used:

In cross 1 motile transductants with antigen *i M6* can be produced by incorporation of a single transduced chromosome fragment by one cross-over in region *a* and one in region *b*, *c* or *d*; if *b* is much shorter than *c* plus *d*, then nearly all such transductants will have the N-methyl-lysine character of the donor strain. In cross 2 one cross-over in *a* and one in *b* or *c* are required; if *b* is not very much shorter than *c*, a substantial proportion of the motile recombinants with antigen *i M6* will have the N-methyl-lysine character of the recipient strain.

Thus the presence or absence of N-methyl-lysine in the flagellar protein produced by bacteria in flagellar antigenic phase 2 is determined by a gene which is not closely linked to the H_2 gene determining the antigenic character of this protein; and in the case of bacteria in phase 1 by a gene closely linked to, but separable from, the H_1 gene determining the antigenic character of the protein produced. The available evidence suggests that *Salmonella* flagella are composed of a single protein. The H_1 and H_2 genes presumably specify not only the antigenic specificities of the phase 1 and phase 2 flagellar proteins but also their complete amino-acid sequences, because flagella of different antigenic types differ in some physical properties, in relative abundance of certain amino-acids and in the peptide 'maps' given by their enzymatic digests (Ambler and McDonough, unpublished results). If this is so, then the control of the presence or absence of N-methyl-lysine in these proteins by a gene other than H_1 or H_2 is in accordance with predicate (*b*) above, that the genetically determined presence or absence of an uncommon amino-acid in a particular

protein cannot be controlled by the gene which specifies the amino-acid sequence of this protein. The experimental results are thus compatible with the hypothesis that only twenty different base-groups specifying amino-acids occur in DNA.

The proteins of *Salmonella* other than flagellar protein do not contain N-methyl-lysine in detectable amounts. The gene determining the presence of N-methyl-lysine in flagellin, but no other protein, perhaps causes the production of an enzyme which methylates the ε-amino-groups of certain lysine radicals in flagellin already formed. Experiments to test this hypothesis are being made.

We thank Prof. J. Lederberg and Dr. N. Datta for providing some of the recombinant strains used.

[1] Crick, F. H. C., *Symp. Soc. Exp. Biol.*, **12**, 138 (1958).
[2] Ambler, R. P., and Rees, M. W., *Nature*, **184**, 56 (1959).
[3] Zinder, N. D., and Lederberg, J., *J. Bact.*, **64**, 679 (1952).
[4] Stocker, B. A. D., Zinder, N. D., and Lederberg, J., *J. Gen. Microbiol.*, **9**, 410 (1953).
[5] Lederberg, J., and Edwards, P. R., *J. Immunol.*, **71**, 232 (1953).

CYTOLOGY OF CELLS WHICH SYNTHESIZE PROTEIN

By M. S. C. BIRBECK and Dr. E. H. MERCER
Chester Beatty Research Institute, Institute of Cancer Research, Fulham Road, London S.W.3

THE cells found in glands which synthesize and secrete protein have been very extensively studied by biochemists and cytologists with the object of discovering the cellular processes associated with protein synthesis. In this article we wish to describe and comment on the fine cytology of another, but less-studied, class of cells which synthesize protein. These, in contrast to secretory cells, retain their product within their plasma membrane and do not secrete it. Examples are the cells of the mammalian epidermis which make keratin, the myoblast which forms the muscle proteins and the erythroblast which forms haemoglobin. For want of a better name we shall call these cells 'retaining cells'. As well as these examples of cells which synthesize specific proteins there are others which have a similar cytoplasmic structure. These are cells with a high rate of growth, for example, animal embryonic cells, plant meristematic tissue, bacteria and many tumours. In these cases the protein synthesized is their own cellular protein.

The Secretory Cell

Examination on the electron microscope of thin sections of secretory cells has revealed in many of them systems of membranes to which are attached numerous dense particles 100-200 Å. in diameter (Fig. 1*a*). The almost simultaneous discovery of these structures by several groups, who each introduced their own terms, has produced a complex nomenclature. The two most commonly used terms, 'endoplasmic reticulum'[1] and 'ergastoplasm'[2], are a source of further confusion, in that, whereas some authors use them to describe membranes with particles, others include those membranes in the cell which are 'smooth' or 'agranular' and are not covered by particles. The presence in the cell of these different types of membranes make us, at least for the present, favour the Sjöstrand nomenclature[3], which defines the particle-covered membranes as 'α-cytomembranes', the external plasma membrane and infoldings of it as 'β-cytomembranes', and the smooth membranes found in the Golgi zone of the cell as 'γ-cytomembranes'. The particles themselves have at least three names (namely, Palade, RNP or microsomal particles). The use of the terms 'microsomes' and 'ribosomes' is inadvisable since these terms are operational terms for specifying biochemical fractions and are not therefore synonymous with morphological structures.

Porter[4] was one of the first to point out the correlation between α-cytomembranes in a cell and basophilia. The integrated biochemical and electron microscopic studies of Palade and Siekevitz[5] showed that α-cytomembranes are the main component of the microsome fraction of the cell, and furthermore that the particles are found in the ribosome fraction. It was therefore inferred that the particles are the site of much of the cytoplasmic ribonucleic acid, the relationship of which to protein synthesis is generally accepted[6,7].

The presence of the particles in these cells is therefore understandable, but the function of the membranes is more obscure. Some have suggested[8,9] that they may provide an interconnected pathway in the cell which is required to guide both raw materials and products of protein synthesis from one site in the cell to another. Inter-connexions between the different membrane systems are occasionally seen; however, evidence that all the membranes are connected (that is, to form a reticulum), which

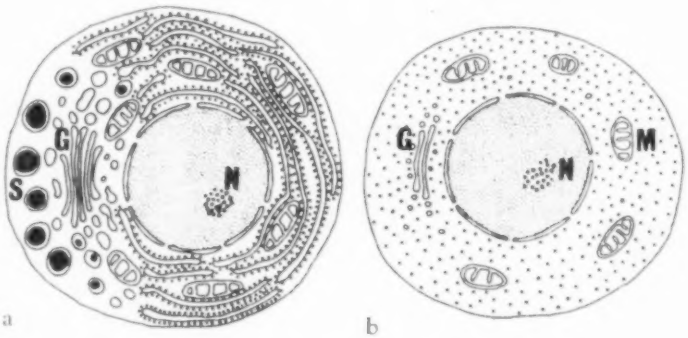


Fig. 1. The fine cytology of the two kinds of cells forming protein: (*a*) the secretory cell, and (*b*) the retaining cell. *M* are mitochondria, *N* nucleoli within the nuclei, *G* clusters of Golgi membranes. The characteristic organelle of the secretory cell is the α-cytomembrane or membrane covered with particles. In the secretory cell the particles are free and there are few α-cytomembranes. In the latter type of cell the synthesized protein appears freely throughout the cytoplasm and is not contained in vesicles

could only be obtained from serial sections, is still lacking. The membranes could also function as a support to localize enzymes[10]; they would represent the cytoskeleton described by Peters[11]. A recent comprehensive review of these structures by Haguenau[12] covers both the microscopical and the biochemical observations.

Nearly all the electron micrographs of these structures have been made after using osmium tetroxide as a fixative, which is particularly satisfactory for delineating both membranes and particles. Other fixatives give different images; for example, permanganate fixation[13] reveals only the membranes, and formalin fixation (unpublished work) shows only the particles; in this latter case the particles are arranged in sheets, so that one would infer that the membranes are preserved but lack sufficient electron density to be visualized. Recent observations by Sjöstrand and Hanzon[14] on frozen-dried tissue have indicated that, after this method of fixation, no particles are seen, but instead a continuous layer of electron-dense material. Assuming that this method of fixation is the most likely to preserve the structure of the living cell, it has been suggested that the particles are an artefact of osmium fixation. However, the similar and regular size of the particles as shown both by electron microscopy and by ultracentrifugation makes it unlikely that they are a random aggregate of material. An alternative explanation would be that the particles extend over a much larger volume in the cell than the micrograph of the specimen fixed with osmium tetroxide would suggest; this would be expected if they had a large degree of hydration.

Retaining Cells

The successful correlation of many structural aspects of secretory cells with biochemical data has tended to obscure the fact that it applies only to this particular class of cells. The other group of protein-synthesizing cells, the retaining cells, prove to have a very different appearance in the electron microscope, for in these the elaborate system of membranes covered with particles (α-cytomembranes) is not present (Fig. 1*b*). Dense particles similar to those found on the α-cytomembranes in secretory cells are numerous, but in retaining cells they are freely dispersed in the cytoplasm. The distribution of particles corresponds to the diffuse basophilia of these cells.

We originally observed that the cells of the hair cortex, where the fibrous protein keratin is synthesized and retained in the cell, had this type of cytoplasmic structure[15]. This led us to study other cell systems which also retain the protein they synthesize. The cells studied are noted in Table 1. From our observations we are able to make some general comments about these cells.

Retaining cells are not devoid of membranes; a nuclear membrane with typical 'pores', and a plasma membrane, are always present. Moreover, a cluster of smooth γ-membranes in the Golgi region of the cell is usually seen. Indeed there is much evidence for regarding this system of membranes as a universal cell structure. However, the characteristic feature of these cells is always the large number of free particles; from this it follows that these particles, which are not necessarily attached to membranes, are the essential cytoplasmic element associated with protein synthesis. Another feature of these

Table 1

	Type of cell	Product
Cells synthesizing specific protein	Epidermal cells:	
	skin	Keratin
	hair cortex	Keratin
	hair inner root sheath	Keratohyalin
	Erythroblasts	Hæmoglobin
	Developing muscle cells	Actomyosin
Rapidly proliferating cells	Embryonic cells	General cellular protein
	Tumour cells	
	Lymphocytes	
	Meristematic plant cells	
	Bacteria	

cells is that the protein, the product of synthesis, is not enclosed in a membrane; whereas in secretory cells a membrane either encloses the secretory granule or alternatively the protein appears inside the distended vesicles of the α-cytomembranes (*S*, Fig. 1*a*). The absence of limiting membrane in retaining cells is perhaps connected with the fact that the protein does not pass through the plasma membrane.

The examples of retaining cells in Table 1 may themselves be divided into two classes. The first examples are cells the cytoplasm of which becomes filled with a specific protein. During the period of protein synthesis the cells contain free particles, but eventually the cytoplasm becomes completely filled with the protein and the particles disappear. The resultant cell is a fully differentiated one, and does not afterwards divide. The second group of cells are those with a high rate of cell division; the protein synthesized in these cells is the cellular protein required for growth. This second type of retaining cells includes several groups of cells, which it is convenient to discuss separately.

Embryonic and Tumour Cells

Embryonic cells and ova have a mixed cytoplasmic pattern (Mercer, E. H., and Wolpert, L., unpublished work), both free particles and particles attached to membranes being present. Free particles at first predominate, but as cleavage and differentiation proceed, a separation into secreting and retaining cells emerges. (See also Slautterback and Fawcett[15*a*].)

Tumour cells may be of either type. Tumours derived from retaining type cells, for example, epidermal carcinomas (Mercer, E. H., unpublished work), have the corresponding cytoplasmic structure. Primary tumours, which are derived from secretory cells and which are sufficiently well differentiated to retain their secretory ability, for example plasma cell tumours[16], contain α-cytomembranes. Those tumours, however, although perhaps originally well differentiated, that have lost their secretory ability, are of the retainer type[17]. These would include most of the anaplastic animal tumours maintained by serial grafting, both in the solid and in the ascites form, as our own work has shown (Mercer, E. H., and Easty, G. C., unpublished work). This reversion of tumour cells to the cytoplasmic pattern of embryonic cells correlates with many of their other properties.

Plant Tissues

Plant meristem tissue contains high concentrations of free particles[18] and may thus be regarded as of the retaining-cell type. Some reports[19,20] claim the presence of endoplasmic reticulum, but the use of this all-inclusive term fails to make clear whether

the authors refer to α-membranes covered with particles or γ-membranes with smooth surfaces. Our own observations (Mercer, E. H., and Mercer, F. V., unpublished work) on developing root tips (maize) reveal small amounts of α- and γ-cytomembranes in some cells, suggesting that initially the cell cytology is generalized. Because plant cells do not commonly secrete protein, the absence of α-cytomembranes is to be expected; their occurrence in those rare plant cells which do secrete would be added corroboration of their required presence in secretory cells. We have examined (with Prof. W. O. James and Dr. R. M. Leach, Botany Department, Imperial College) the scutellum of germinating barley seeds. These cells produce the enzymes required for the breakdown of the endosperm. Our results show that the cytoplasm of these cells has an appearance nearer that of animal secretory cells than that of typical plant cells. Membranes covered with particles are present, although some free particles exist also.

Bacteria

Recent electron micrographs of bacteria[21,22] show free particles embedded in the dense amorphous cytoplasmic region of the cell. It is possible that the particles are smaller than those in animal cells, but the good correlation between these particles and the isolated ribosomes[23] is sufficient to regard them as a site of RNA in the cell and therefore analogous to the particles in animal cells. Bacteria therefore have the cytoplasmic pattern of retaining cells, although their cytology in other respects is very different: the absence of a nuclear membrane and of mitochondria is most obvious. Brieger *et al.*[24] have described membranes in some Mycobacteria, but these are of the smooth type. Although the presence of free particles agrees well with the rapid growth-rate of bacteria, the absence of membranes makes it difficult to explain bacterial secretion. That enzymes do appear in the extracellular medium is undoubted; either the mechanism of secretion must differ from that in animal cells or perhaps extracellular protein is liberated by lysis of the whole cell. This latter method of 'holocrine' secretion does occur in bacteria[25], but evidence that it is the only mechanism is lacking.

Protozoa

Many Protozoa contain elaborate organelles based on membranes, as might be expected from their complex intracellular differentiation. Two types of amœba studied by us are of interest. *A. proteus* has organelles based on smooth γ-membranes, but no α-cytomembranes[26]. The social amœbæ, *Dictyostelium* and *Polysphondylium*, which from their elaborate life-histories might be expected to secrete, have small amounts of α-cytomembranes[27].

Other Implications

The belief that all cells have an internal structure resembling that of the secretory cell is largely responsible for the speculation that all the membranes of the cell are interconnected to form a single system. The external plasma membrane may also be included in this system[28]. While this speculation is supported by evidence that all membranes have a common phospholipid-protein structure, and while transient interconnexions probably do occur, it is difficult to believe that there are any permanent interconnexions in retaining cells. The connexion between the cytoplasmic membranes and the nuclear membrane has been regarded as a means[29] by which nuclear RNP particles are transferred to the cytoplasm. The absence of this connexion in retaining cells, which nevertheless have a fenestrated nuclear membrane similar to that of secretory cells, makes it likely that some other mechanism of transfer of RNA must exist.

While nearly all the protein-producing cells yet examined belong to either of the two types we have described, we would not wish to imply that they represent the only two possibilities. In at least one tissue[30], the colleterial glands of the cockroach, part of which synthesizes an oxidase required to tan the structural protein of the egg case, there is a possibility that the enzyme is produced by mitochondrial proliferation. If this were so, it would be similar to the protein synthesis which occurs in mitochondria[31], which does not appear to contain RNP particles.

This work has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the Medical Research Council, the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

[1] Porter, K. R., and Kallman, F. L., *Ann. N.Y. Acad. Sci.*, **54**, 882 (1952).
[2] Bernhard, W., Haguenau, F., Gautier, A., and Oberling, C., *Z. Zellforsch. u. Mikroskop. Anat.*, **37**, 281 (1952).
[3] Sjöstrand, F. S., *Int. Rev. Cytol.*, **5**, 455 (1956).
[4] Porter, K. R., *J. Hist. and Cytochem.*, **2**, 346 (1954).
[5] Palade, G. E., and Siekevitz, P., *J. Biophys. Biochem. Cytol.*, **2**, 671 (1956).
[6] Brachet, J., *Biochemical Cytology* (Acad. Press, New York, 1957).
[7] Caspersson, T. O., *Cell Growth and Cell Function* (Norton, New York, 1950).
[8] Palade, G. E., *J. Biophys. Biochem. Cytol.*, **2**, Supp. 85 (1956).
[9] Bennett, H. S., *J. Biophys. Biochem. Cytol.*, **2**, Supp. 99 (1956).
[10] Lehninger, A. L., *Developmental Cytology*, edit. Rudnick, D. (The Ronald Press Co., New York, 1959).
[11] Peters, R. A., *Perspectives in Biochemistry*, edit. Needham, J., and Green, D. E., 36 (Camb. Univ. Press, 1937).
[12] Haguenau, F., *Int. Rev. Cytol.*, **7**, 425 (1958).
[13] Luft, J. H., *J. Biophys. Biochem. Cytol.*, **2**, 799 (1956).
[14] Hanson, V., and Sjöstrand, F. S., *J. Ultrastructure Res.*, **3**, 234 (1959).
[15] Birbeck, M. S. C., and Mercer, E. H., *J. Biophys. Biochem. Cytol.*, **3**, 203, 215, 223 (1957).
[15a] Slautterback, D. B., and Fawcett, D. W., *J. Biophys. Biochem. Cytol.*, **5**, 441 (1959).
[16] Braunsteiner, H., Fellinger, K., and Pakesch, F., *Blood*, **12**, 278 (1957).
[17] Howatson, A. F., and Ham, A. W., *Cancer Research*, **15**, 62 (1955).
[18] Ts'o, P. O. P., Bonner, J., and Vinograd, J., *J. Biophys. Biochem. Cytol.*, **2**, 451 (1956).
[19] Buvat, R., and Carasso, N., *C.R. Acad. Sci., Paris*, **244**, 1532 (1957).
[20] Setterfield, G., Stern, H., and Johnson, F. B., *Canad. J. Bot.*, **37**, 65 (1959).
[21] Kellenberger, E., and Ryter, A., *J. Biophys. Biochem. Cytol.*, **4**, 323 (1958).
[22] Mercer, E. H., *Biochem. Biophysica Acta*, **34**, 84 (1959).
[23] Hall, C. E., and Slayter, H. S., *J. Mol. Biol.*, **1**, 329 (1959).
[24] Brieger, E. M., Glauert, A. M., and Allen, J. M., *Exp. Cell. Res.*, **18**, 418 (1959).
[25] Barksdale, L., *Bact. Rev.*, **23**, 202 (1959).
[26] Mercer, E. H., *Proc. Roy. Soc.*, B, **150**, 216 (1959).
[27] Mercer, E. H., and Shaffer, B. M., *J. Biophys. Biochem. Cytol.*, **7**, 353 (1960).
[28] Robertson, J. D., *Biochem. Soc. Symp.* (1957), edit. Crook, E. M., **16**, 3 (Camb. Univ. Press, 1959).
[29] Watson, M. L., *J. Biophys. Biochem. Cytol.*, **1**, 257 (1955).
[30] Mercer, E. H., and Brunet, P. C. J., *J. Biophys. Biochem. Cytol.*, **5**, 257 (1959).
[31] Bates, H. M., Craddock, V. M., and Simpson, M. V., *J. Amer. Chem. Soc.*, **80**, 1000 (1958).

The Rotation of the Earth

W. H. MUNK AND G. J. F. MACDONALD

A unified treatment of the rotation of the Earth. The authors give an account of certain observed irregularities in the Earth's rotation, caused by events on and within the Earth, and providing a means of studying a number of geophysical problems. *Cambridge Monographs on Mechanics and Applied Mathematics.* 70*s. net*

Classical Electricity & Magnetism

E. S. SHIRE

This textbook is designed to bridge the gap between the elementary account of classical electricity and magnetism taught in schools and a mathematical treatment based on Maxwell's equations. It goes slightly beyond the standard of a general degree course in physics and engineering. The book may be used with both M.K.S. and c.g.s. systems. 45*s. net*

CAMBRIDGE UNIVERSITY PRESS

Periodical Publications of The Institute of Physics and The Physical Society

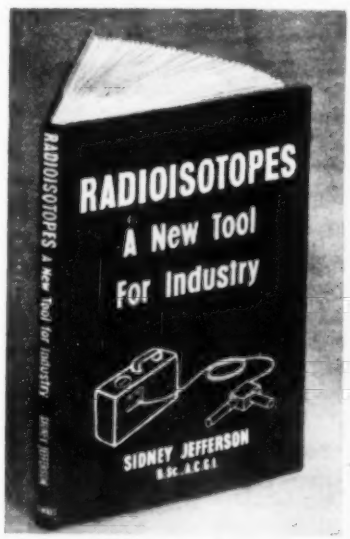
Journal of Scientific Instruments
A monthly publication dealing with the principles, construction, and use of scientific instruments. £6 per annum

British Journal of Applied Physics
A monthly publication dealing with applications of physics, especially in industry. £6 per annum

Proceedings of the Physical Society
A monthly publication containing papers describing original work in physics. £12 12*s.* per annum

Reports on Progress in Physics
An annual publication containing comprehensive reviews issued in April. £4 4*s.* per annum

Available from:
47 BELGRAVE SQUARE, LONDON, S.W.1



By
SIDNEY JEFFERSON
B.Sc., A.C.G.I.
Leader of the Technological Irradiation Group, Isotope Research Division, A.E.R.E., Wantage.

Foreword by
Dr. HENRY SELIGMAN
O.B.E.
Deputy Director-General for Isotopes and Research, International Atomic Energy Agency, Vienna.

2nd Edition

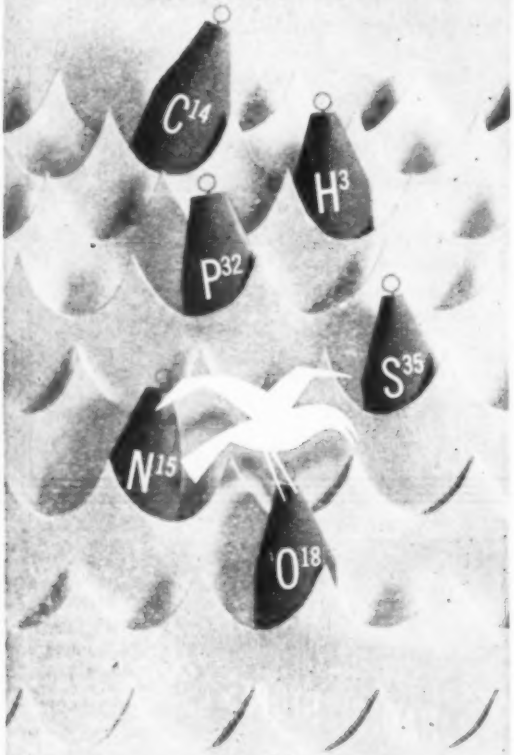
21s. net

From all booksellers or in case of difficulty at 22s. by post from George Newnes Ltd., Tower House, Southampton Street, London, W.C.2.

New chapters cover liquid flow measurement, mechanical and geological applications, direct production of electricity from radiation, luminescent materials and gamma radiation processing. It includes accounts of interesting new projects undertaken by the author and his colleagues. Illustrated throughout.

NEWNES

markers to delineate biologic channels



MANY TYPES OF LABELED BIOCHEMICALS AVAILABLE FROM SCHWARZ. If you are mapping metabolic pathways, investigating enzyme mechanisms, or exploring many other areas of biology and biochemistry, SCHWARZ isotopically-labeled biochemicals are useful markers. We have attached C^{14}, H^3, P^{32}, and S^{35} to a long list of purine and pyrimidine compounds, sugars and sugar phosphates, amino acids, metabolic cofactors and other compounds of biologic importance. Many radiochemicals are supplied exclusively by SCHWARZ.

Also available is a wide range of N^{15}-labeled compounds. Through an arrangement with the Yeda company at the Weizmann Institute, a number of O^{18} amino acid derivatives can be prepared on special order. For a complete price list, write to Dept. BH.

SCHWARZ BIORESEARCH, INC.
Mount Vernon, New York
BIOCHEMICALS • RADIOCHEMICALS • PHARMACEUTICALS
for research, for medicine, for industry

SOIL SAMPLERS

Hiller pattern Peat Sampler, Mattsons' Swedish make. Available complete with extension rods as illustrated.

Write for details "N.S." of shorter Samplers including Walking-stick model: also of Pressler Borers for wood-tests, etc.

J. H. STEWARD, LTD.
Contractors to Crown Agents, Universities, etc.
406, Strand, London, W.C.2
TEM. 1867 ESTAB. 1852

GLASS

All Glass Requirements for Scientific Instrument Manufacturers and Research Workers

- SHEET & PLATE-GLASS—cut and ground to exact dimensions.
- LENSES, PRISMS & FLATS—to any standard of accuracy.
- MIRRORS—back silvered and front surface aluminised, etc.
- BLOOMING of optical components.

C. J. WHILEMS, LTD.
ILFORD OPTICAL WORKS
FOREST ROAD, BARKINGSIDE, ESSEX

Telephone: HAInault 5454-5

MACMILLAN BOOKS

Russia's Rockets and Missiles

ALBERT PARRY

In this important book the Russian-born author, one of the foremost American experts on Soviet rocketry, presents a fascinating and authoritative account of Russian efforts to master outer space. He also takes a look into the future, including plans for Soviet lunar cities and visits to other planets. *25s*

Elements of Physical Chemistry

SAMUEL GLASSTONE and DAVID LEWIS

In this revised edition the contents have been rearranged to provide a more logical presentation, whilst new material has been incorporated in each chapter. The book provides, at the elementary and within the scope of a degree course, a comprehensive physical chemistry in the light of modern developments in the science.

Over 200 figures and tables. Second Edition. 60s

The Interpretation of X-ray Diffraction Photographs

N. F. M. HENRY, H. LIPSON and W. A. WOOSTER

Since the publication of the first edition there has been a considerable development of direct-projection methods of X-ray diffraction. In this new edition chapters have been added on the precession method and on rotation-retigraph method. Chapters on the Weissenberg method have been rewritten and enlarged and minor changes have been made throughout the text. *Illustrated with photographs and diagrams. Second Edition. 63s*

Structural Concrete

KURT BILLIG

Following Professor Billig's previous books, *Prestressed Concrete* and *Precast Concrete*, this present work aims to provide a *Minor Encyclopaedia on Structural Concrete* within a single volume. The layout of the book follows the scheme established by its predecessors, with materials, design, and construction dealt with in that order.

164 figures, 73 photographs, 113 tables. 84s

ST MARTIN'S STREET LONDON WC2

ACADEMIC PRESS New York and London

*Special Offer** *In 2 volumes*

Milk: the Mammary Gland and Its Secretion

Edited by S. K. KON *and* A. T. COWIE
National Institute for Research in Dairying, Shinfield, Reading, England

The scope and depth of coverage make these volumes a unique treatise which will be invaluable to the research worker and to the advanced student in this important field. Fully documented, the volumes will serve not only as an up-to-date and authoritative presentation of the scientific basis of our modern knowledge about milk, but also as a valuable work of reference. The book is not concerned with the technology of milk or milk products.

Volume 1 *February* 1961, 515 *pp., illus.*

* *Special price in effect until May* 31, 1961, 90*s.* *Thereafter*, 100*s.*

The Mammary Gland: Morphogenesis, Structure and Growth

Morphogenesis of the Mammary Gland
By ALBERT RAYNAUD

Histology and Cytology of the Mammary Gland
By GASTON MAYER *and* MARC KLEIN

Hormonal Regulation of Mammary Gland Growth
By DORA JACOBSOHN

Functional Physiology of the Mammary Gland

The Hormonal Control of Milk Secretion
By A. T. COWIE

Biochemistry of Prolactin
By CHOH HAO LI

Neural Control of Lactation
By B. A. CROSS

Lactation in Man and Farm Animals

Human Lactation
By MICHAEL NEWTON

Farm Animals: Hormonal Induction of Lactation and Galactopoiesis
By J. MEITES

Biochemical Activities of the Mammary Gland

General Biochemistry of Mammary Tissue
By R. G. HANSEN *and* D. M. CARLSON

Protein Metabolism
By J. M. BARRY

The Biosynthesis of Lactose
By LUIS F. LELOIR *and* CARLOS E. CARDINI

Biosynthesis of Milk Fat
By S. J. FOLLEY *and* MARY L. MCNAUGHT

AUTHOR INDEX—SUBJECT INDEX.

Volume 2 *March* 1961, 423 *pp., illus.*

* *Special price in effect until May* 31, 1961, 77*s.* 6*d.* *Thereafter*, 86*s.*

Nutrition of the Lactating Animal

Nutrition of the Lactating Woman
By F. E. HYTTEN *and* A. M. THOMSON

Nutrition of Lactating Farm Animals
By J. T. REID

Metabolic Disturbances Associated with Lactation
By J. C. SHAW

Dietary Requirements for Lactation in the Rat and Other Laboratory Animals
By MARJORIE M. NELSON *and* HERBERT M. EVANS

Nutritional Value of Milk

The Composition of Milk and the Nutritive Value of Its Components
By E. R. LING, S. K. KON *and* J. W. G. PORTER

Human Milk and Cow's Milk in Infant Nutrition
By ICIE J. MACY *and* HARRIET J. KELLY

Lactation and the Growth of the Young
By K. L. BLAXTER

Immunological Aspects of Colostrum
By R. LOVELL *and* T. A. REES

AUTHOR INDEX—SUBJECT INDEX.

Phone: WHitehall 6631

111 FIFTH AVENUE, NEW YORK 3 17 OLD QUEEN STREET, LONDON, S.W. 1

111 FIFTH AVENUE, NEW YORK 3 17 OLD QUEEN STREET, LONDON, S.W. 1

"Surely destined to become one of the classics of biochemistry."—*Science*

The Enzymes

Second Edition, completely revised and reset

Edited by PAUL D. BOYER, *University of Minnesota*
HENRY LARDY, *University of Wisconsin*
KARL MYRBACK, *University of Stockholm*

In 7 volumes **Fifteen per cent price reduction on orders for the complete set received before publication of the last volume**

Volume 5 Hydrolytic Cleavage (Part B)
Phosphate Ester Cleavage
Acid Anhydride Cleavage
Phosphorylytic Cleavage
C—C Synthesis and Cleavage
Isomerization
Hydration and Dehydration

April 1961, 645 *pp., illus., approx.* 130*s.*

CONTENTS:

Phosphate Ester Cleavage (Survey)
By G. SCHMIDT *and* M. LASKOWSKI

Nonspecific Phosphomonoesterases
By GERHARD SCHMIDT

5′-Nucleotidase
By LEON A. HEPPEL

Alkaline Phosphatases
By THERESSA C. STADTMAN

Glucose-6-Phosphatase and Phosphoserine Phosphatase
By WILLIAM L. BYRNE

Phosphodiesterases
By H. GOBIND KHORANA

The Ribonucleases: Occurrence, Structure, and Properties
By C. B. ANFINSEN *and* F. H. WHITE, JR.

Deoxyribonucleases
By M. LASKOWSKI

Acid, Anhydride Hydrolysis (Survey)
By W. WAYNE KIELLEY

Myosin Adenosine Triphosphatase
By W. WAYNE KIELLEY

Inorganic Pyrophosphatases
By MOSES KUNITZ *and* P. W. ROBBINS

Phosphorylases (Survey)
By MILDRED COHN

Animal and Plant Polysaccharide Phosphorylases
By DAVID H. BROWN *and* CARL F. CORI

Disaccharide Phosphorylases
By M. DOUDOROFF

Nucleoside Phosphorylases
By MORRIS FRIEDKIN *and* HERMAN KALCKAR

Polynucleotide Phosphorylase
By M. GRUNBERG-MANAGO

Pyrophosphorylases
By J. IMSANDE *and* P. HANDLER

Cleavage and Synthesis of Carbon-to-Carbon Bonds (Survey)
By E. RACKER

Nonoxidative Carboxylation and Decarboxylation
By MERTON F. UTTER

Aldolase
By WILLIAM J. RUTTER

Oxacetate Transacetase (Condensing Enzyme, Citrogenase)
By JOSEPH R. STERN

Thiolase
By G. HARTMANN *and* F. LYNEN

Isocitric Lyase
By JAMES ALLEN OLSON

Transketolase
By E. RACKER

Transaldolase
By E. RACKER

Isomerization Reactions (Survey)
By YALE J. TOPPER

Aldose-Ketose Transformations
By YALE J. TOPPER

Enzymic Epimerizations
By E. S. MAXWELL

Hydration and Dehydration (Survey)
By BO G. MALMSTRÖM

Enolase
By BO G. MALMSTRÖM

Aconitase
By SHERMAN R. DICKMAN

Crotonase
By JOSEPH R. STERN

Fumarase
By ROBERT A. ALBERTY

Carbonic Anhydrase
By ROBERT P. DAVIS

Serine, Threonine, and Homoserine Dehydrases
By DAVID M. GREENBERG

AUTHOR INDEX—SUBJECT INDEX.

Previously published:

Volume 1: **Kinetics, Thermodynamics, Mechanism, Basic Properties** 1959, 785 *pp., illus.*, 171*s.* 6*d.*

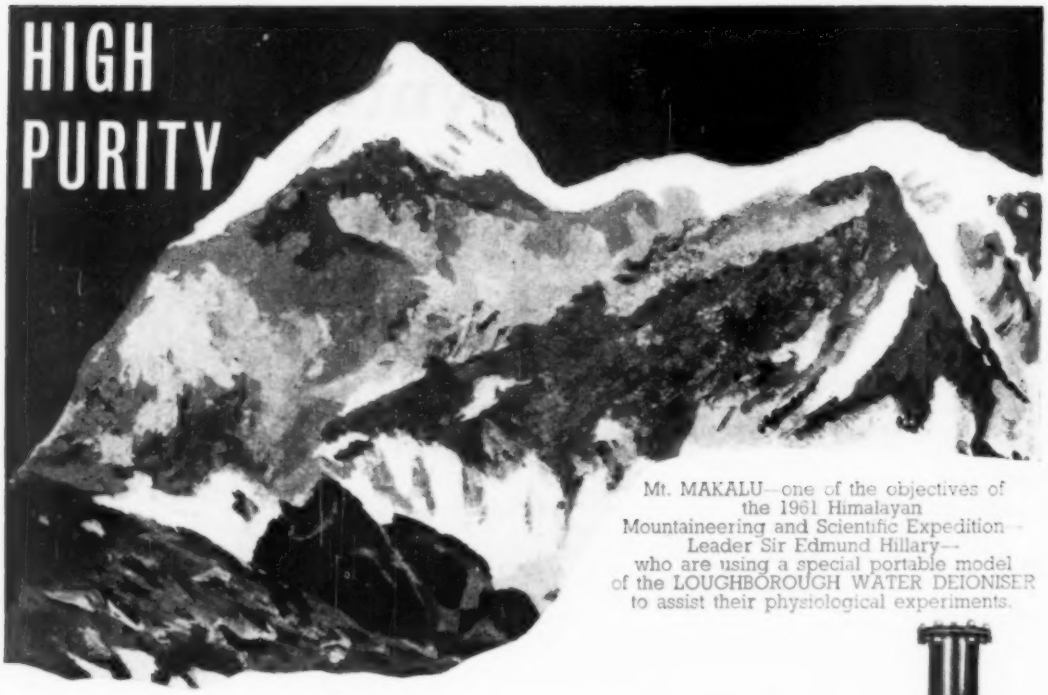
Volume 2: **Purine and Pyrimidine Nucleotides, Phosphagens Prosthetic Groups and Cofactors** (Part A) 1960, 479 *pp., illus.*, 114*s.* 6*d.*

Volume 3: **Prosthetic Groups and Cofactors** (Part B) 1960, 497 *pp., illus.*, 114*s.* 6*d.*

Volume 4: **Hydrolytic Cleavage** (Part A) 1960, 631 *pp., illus.*, 128*s.* 6*d.*

Volumes 6 *and* 7, *in preparation*

ACADEMIC PRESS London and New York



Mt. MAKALU—one of the objectives of the 1961 Himalayan Mountaineering and Scientific Expedition—Leader Sir Edmund Hillary—who are using a special portable model of the LOUGHBOROUGH WATER DEIONISER to assist their physiological experiments.

FOR HIGH PURITY WATER

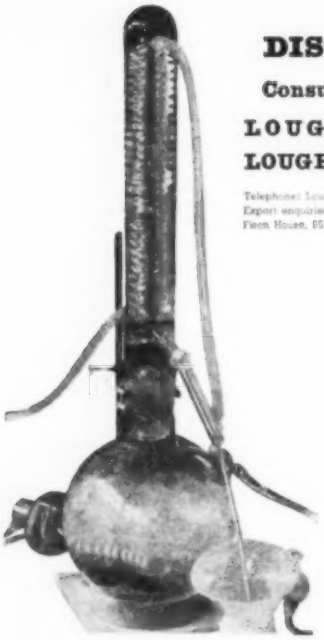
by

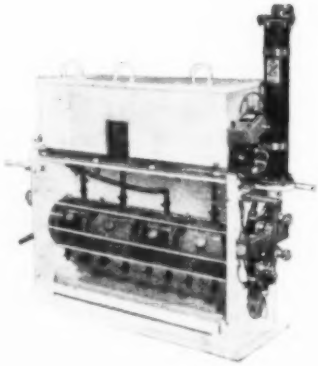
DISTILLATION or DEIONISATION

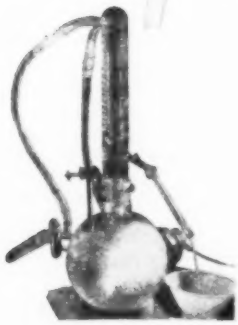
Consult:

LOUGHBOROUGH GLASS COMPANY Ltd.,
LOUGHBOROUGH, LEICESTERSHIRE, ENGLAND

Telephone: Loughborough 4881 Telegrams: Glass Telex Loughborough Telex: 34629
Export enquiries to: Fisons Chemicals (Export) Ltd.,
Fison House, 65 Wigmore Street, London, W.1.



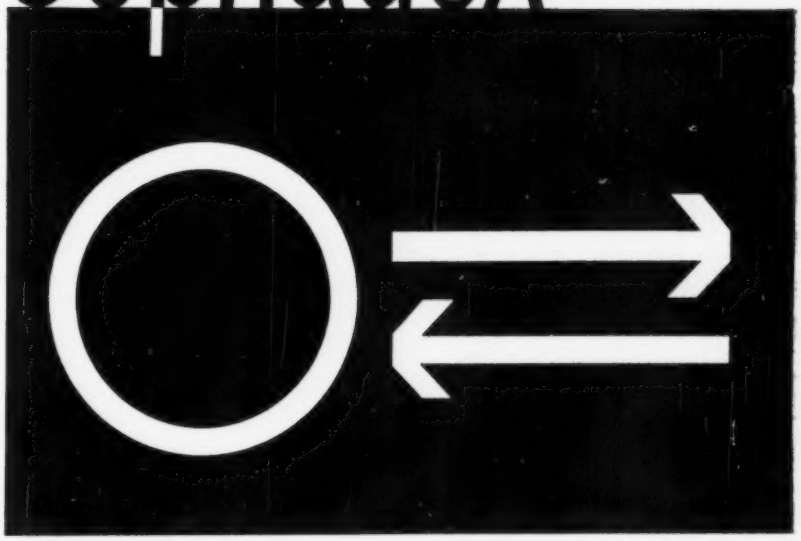




U1 2

ION EXCHANGE with

Sephadex



Ionic groups in Sephadex have given a range of ion exchangers the first of which is

DEAE-SEPHADEX

an anion—exchanger
available in two types

A 25

A 50

each type in sieve fractions:

Coarse

Medium

Fine

Properties:

high capacity even for large molecules

low non-specific adsorption

Applications:

serum proteins · peptides
nucleic acids · nucletoides
polysaccharides

PHARMACIA UPPSALA SWEDEN

Send for our booklet.

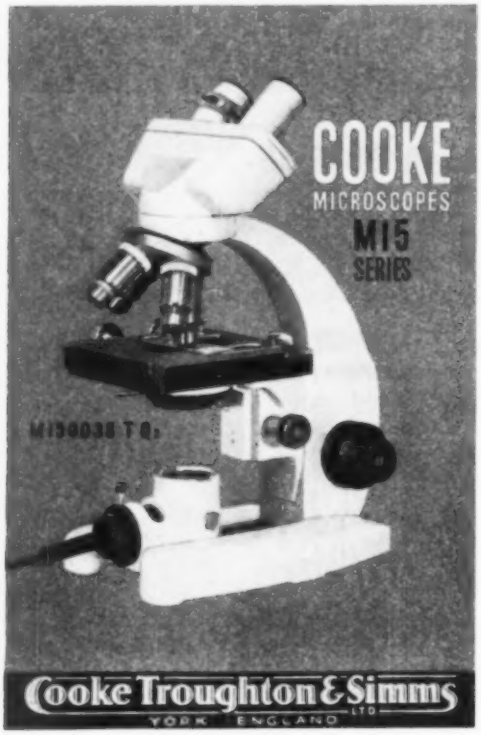
Representatives

AUSTRIA: *Contex Ges. m. b. H., Wien 1, Wipplingerstrasse 25* · AUSTRALIA: *Andrew Thom, Ltd., Athom House, 261 Broadway, Sydney* · BELGIUM: *N. V. Société Belge d'Optique, 108, Rue de la Prairie, Gent* · DENMARK: *A/S Pharmacia, Lindeallé 48, Copenhagen — Vanlöse* · FINLAND: *Pharmacia Oy, Alexandergatan 48, Trappa A5, Helsingfors* · FRANCE: *Jaire-Jacquin, Recherches et Laboratories, 18, Rue Pierre Curie, Paris (V^e)* · GERMANY: *Pharmacia G. m. b. H., Bad Nauheim, Parkstrasse 12* · GREAT BRITAIN: *Savory & Moore, Ltd., 60/61 Welbeck Street, London, W. 1.* · HOLLAND: *Van Oortmerssen N. V., De Ruyterstraat 48, The Haque* · NORWAY: *A B Pharmacias informasjonskontor, c/o Arne Örvig, Darresgate 2, Oslo* · SWITZERLAND: *Opopharma A.-G., Postfach, Zürich 25* · UNITED STATES: *Pharmacia Fine Chemicals, Inc., Sales Office, Box 1010, Rochester, Minn.*

Talking of Breakfast Cereals?

Kraucke's drawing, when we first published it, led to our receiving a fan mail, so we have decided to give away a free copy (beautifully printed on Art Paper) with every order received this month. Whether you order an automatic recording integrating microdensitometer, a new X-ray diffractometer (which embodies Arndt and Philips Rocking device, and has θ, 2θ, φ, and χ angles controlled by a punched tape), or simply a trial order of a few balls and spokes, you will still qualify.

CRYSTAL STRUCTURES LTD., 339 CHERRY HINTON RD., CAMBRIDGE



DILLON'S UNIVERSITY BOOKSHOP Ltd

Bird, Stewart, and Lightfoot, Transport Phenomena 1960. £5 10s

1 MALET ST., LONDON, W.C.1. MUSeum 2128

THE MUSEUM BOOK STORE, LTD.

25 Devonshire St., London, W.1
(Welbeck 1340)

Buy and sell Scientific Journals and Periodicals and Learned Society Publications in all languages. Librarians, and others, should send us their list of "wants", or duplicates for sale. *Binding undertaken.*

WHELDON & WESLEY, LTD.

Specialists for 100 years in

BIOLOGICAL & GEOLOGICAL BOOKS

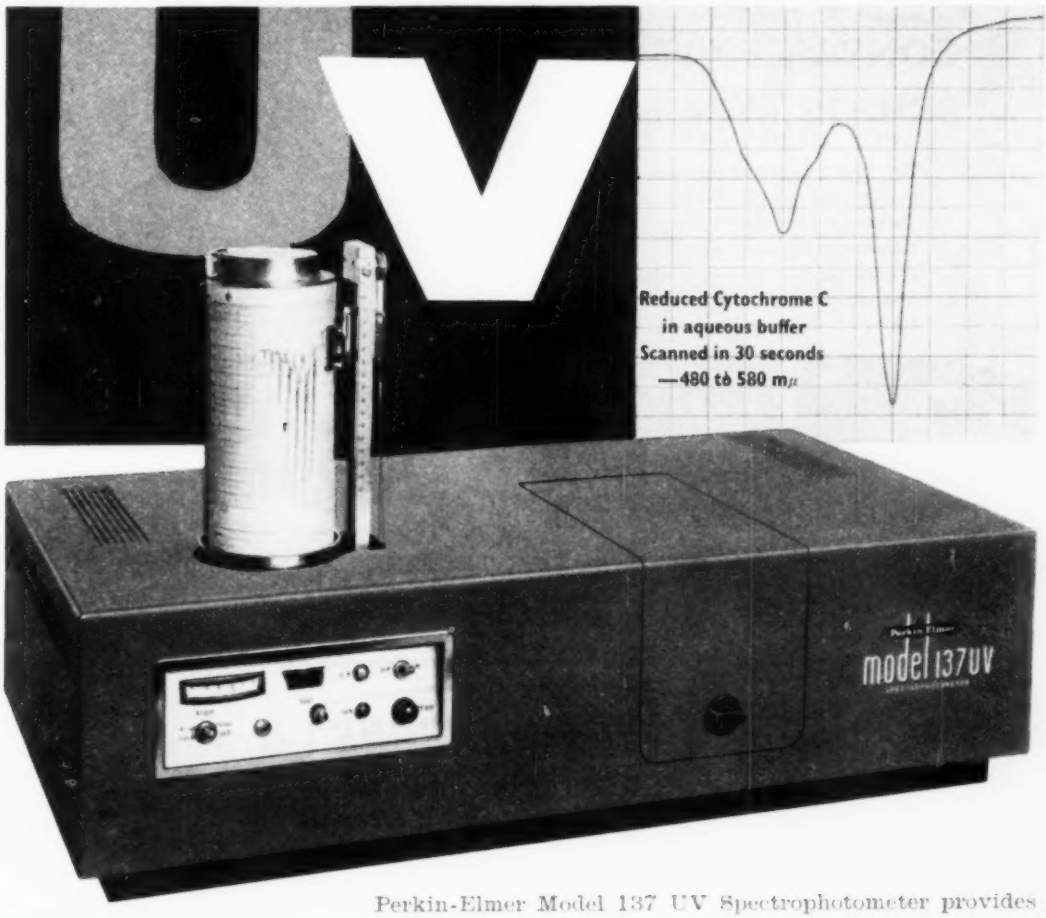
Catalogues on Request

•

LYTTON LODGE, CODICOTE, Near Hitchin, Herts

Books Bought

AUTOMATIC UV



Model 137 UV Spectrophotometer

Versatile, easy to use

Only three controls

Manual setting of drum

No run-back time

Wavelength range: 190mμ to 750mμ

Resolution: 0.2mμ at 250mμ

Repeatability: 0.005 absorbance units

Automatic Gain Control: Compensates absorption of solvent, even if absorption of solvent is 99%

Read-Out Accessory: For constant wavelength read-out on auxiliary recorder

Top Speed: 2 minutes or 8 minutes for full ultraviolet or visible scan

Stray Light: Less than 1% at 210mμ

Size: 32" x 18" x 18" high

Perkin-Elmer Model 137 UV Spectrophotometer provides fully automatic top-speed analysis at remarkably low cost in the ultraviolet and visible. Advanced operating features, including automatic gain control, direct absorbance recording and a read-out accessory, make the Model 137 UV a powerful and valuable instrument for the widest range of applications, both in the laboratory and for continuous production control. It is fast and simple in use, and its accuracy and repeatability are of the highest standard.

We should like to send you full details of this new instrument.

Perkin-Elmer

ANALYTICAL INSTRUMENTS

Beaconsfield, Bucks, England · Telephone Beaconsfield 2020

Lock PORTABLE

CONDUCTIVITY BRIDGE TYPE BC 1

This mains-operated instrument has a bridge frequency of 1500 c/s, and covers the very wide range of 0·05 to 1 × 10⁶ micro mhos in seven ranges.
A portable fully-transistorised bridge is also available. It covers the range of 0·5 to 1 × 10⁶ micro mhos in six ranges.

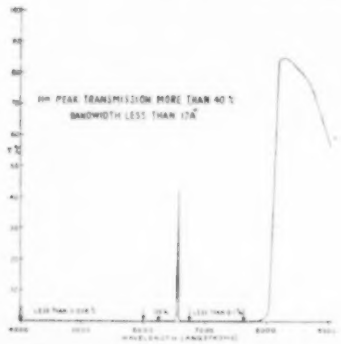
Lock NUCLEAR CHEMICAL ELECTRONIC INSTRUMENTATION

A. M. LOCK & CO. LTD.
Prudential Buildings, 79 Union Street, Oldham, Lancs.
Telephone : MAin 6744

C.W. 7751

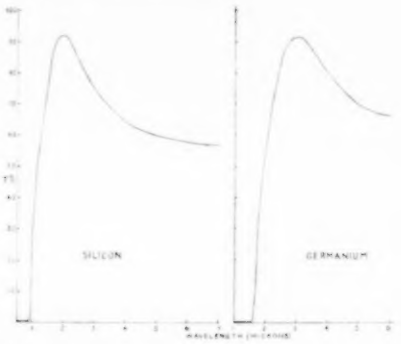
GRUBB PARSONS

OPTICAL FILTERS



NARROW BAND INTERFERENCE FILTERS FOR THE VISIBLE (4500-6600Å)

Bandwidths down to 10Å
Uniformity closely controlled
Diameter 2 inches



SEMI-CONDUCTOR FILTERS FOR THE INFRA-RED

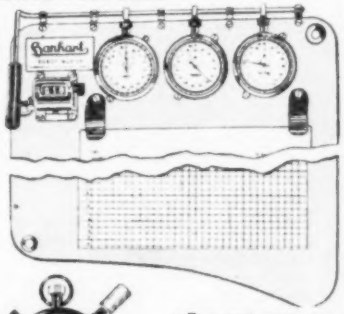
Optically polished and bloomed
Diameter 0·75 inches mounted in 1 inch holder

GRUBB PARSONS • NEWCASTLE UPON TYNE 6 • ENGLAND
(Subsidiary of C. A. Parsons & Co. Ltd.)

Hanhart STOP WATCHES

FOR INDUSTRY, EDUCATION, RESEARCH AND ALL SCIENTIFIC PURPOSES

ALL CALIBRATIONS AVAILABLE



ROBOTIMER
Type 38.10
Each operation automatically starts 'A', zeros 'B' and stops 'C'
£27 10 0.

Split Action Timer
Type 786.5 ⅛ sec.
30 min. recorder
£11 3 6.

Electrically Actuated
4½–7 Volt—All calibrations available

- Dust and water protected.
- Shockproof; unbreakable mainspring.
- Available in any desired calibration.
- Fully guaranteed for 12 months.
- 48 hour return post repair service.
- Your specific enquiries invited.

Fully illustrated catalogue from the Sole U.K. Distributors

CHRONOTIME

(Dept. N.4) · 314, HIGH HOLBORN, LONDON, W.C.1

Telephone—CHANCERY 8655/6

THE ARROW PROJECTION TORCH

The Arrow Projection Torch is designed for use wherever teaching is accompanied by screen illustration. An arrow of high intensity illumination is projected, and may be focused to any distance from 6 to 40 ft.

Now reduced in price

A descriptive and illustrated pamphlet is available and this will be gladly sent on request.

RAYNER

160 NEW BOND STREET, LONDON, W.1

Telephone MAYfair 0128

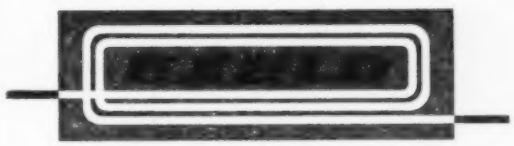
EXELO

REVOLUTIONARY FREE-PISTON BURETTE

The EXELO free-piston burette has brought effortless precision and speed of operation to burette work in the chemical laboratory. Capacity readings of an accuracy of up to one part in five thousand by line on the free floating piston eliminate previous difficulties of meniscus and readings in coloured solutions. The EXELO free-piston burette is fitted with the EXELO three way interchangeable stopcock or conventional three way stopcock.

Designed by
I. C. P. SMITH,
B.Sc., F.R.I.C. & F.S.G.T.

Obtainable from your Laboratory supplier or write for details to:



W. G. FLAIG & SONS LTD

EXELO WORKS MARGATE ROAD

BROADSTAIRS, KENT THANET 61365/6

The place of the Particle Accelerator in Basic Research

Particle Accelerators in Biological Research—III

High-energy charged particles are of great value in the study of biological matter. The effects of ionizing radiation can provide information that is invaluable in the development of models to describe the structure and organization of living matter.

Energy-transfer Mechanism

The basic mechanisms by which incident energy is transferred to the target material are of importance. These mechanisms include the "direct effect", which can be described by the target theory of Lea and others, and the "indirect effect" where the energy is absorbed by the solvent and subsequently transferred by radiation-produced intermediates to the solute. Both of these effects take place within the living cell, as shown by irradiation in the wet and dry states. A knowledge of the kinetics of the indirect effect can be important to consideration of the biological effects of ionizing radiation.

Effects of Light and Heavy Particles

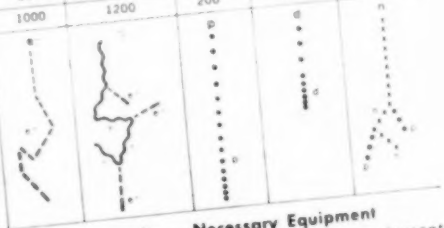
The physical structure of microorganisms such as bacteria and viruses has been studied extensively with ionizing radiation. Light particles, such as electrons or x-rays, are easily scattered in matter and may strike the organism from any direction. Analysis of the inactivation from this type of radiation can give a radio-sensitive volume.

Heavy particles, on the other hand, are not easily scattered and travel in straight lines until they are stopped. Analysis of the inactivation data will give a radio-sensitive cross-section for the organism. From data of this type it has been possible to formulate models that agree with structures developed by other experimental methods.

Characteristics of particles obtainable from Van de Graaff accelerators

	electron	x-ray	proton	deuteron	neutron
Mev	μa	r/min—100cm	μa	μa	n/sec
1	250	20	50	50	2×10^{11}
2	250	75	50	50	10^{11}
3	1000	1200	200	200	1.2×10^{11}

Typical particle trajectory in target material



Effects on Man

In addition to fundamental studies on biological materials, there is a great need for better understanding of the effects of ionizing radiation on man. Extensive studies under way on the effects of radiation on animals are providing data that, extrapolated to man, will help greatly in our current problem of providing protection for persons working in radiation environments such as radiation clinics, reactor facilities, and research laboratories. Knowledge of the tolerance dose and the relative biological effects of all the types of ionizing radiation is essential for our safety and for the fulfillment of the ultimate promise of the atomic age.

Necessary Equipment

The radiation equipment necessary to gain this knowledge depends on the major field of interest. The equipment should be variable in energy, should produce all of the particles which are of interest and should have sufficiently high outputs to produce data in a reasonable period of time. The Van de Graaff® is such a tool. The energies and types of particles it can provide are shown in the table above, with diagrams of their typical modes of energy transfer in matter. The particle energy can be varied from the maximum shown to approximately one tenth of this value. The current is continuously variable from a remote control station. Installation is relatively simple, and the ease of operation and flexibility make it an ideal source of ionizing radiation for biological research.

Write for informative reprints on the effects of charged particles on bacteria

HIGH VOLTAGE SERVICING CO., LTD.
60 Carpenters Wood Dr.
Chorley Wood, Herts.

HVEC ARCO

HIGH VOLTAGE ENGINEERING
CORPORATION
BURLINGTON, MASSACHUSETTS • U.S.A.
APPLIED RADIATION CORPORATION • HIGH VOLTAGE ENGINEERING (EUROPA) N.V.

LETTERS TO THE EDITORS

RADIOASTRONOMY

Secular Variation of the Flux Density of the Radio Source Cassiopeia A

In 1951, Ryle and Elsmore[1] reported on a series of observations of radio sources using an interferometer at a frequency of 81·5 Mc./s. A comparison of the flux densities of about one hundred sources measured nearly every day for eighteen months revealed no long-term variations greater than 10 per cent, or for some of the more intense sources, greater than 5 per cent.

It is now believed that the majority of sources are extra-galactic and would therefore not be expected to show any intrinsic variations over a few years only. A number of sources, however, have been identified with the remnants of galactic supernovæ of comparatively recent origin, and Minkowski[2] has shown that the intense source Cassiopeia A is probably of this type. Optical study of this source is difficult because of heavy obscuration in the region, but his measures of the velocities of the faint visible filaments suggest that the supernova exploded 258 ± 14 yr. ago. There is clearly the possibility of being able to detect a change in the intensity of this source.

Some observations for this purpose were carried out in Cambridge in 1956 with apparently positive results, but it was felt that further confirmation was required. This has recently been obtained and reveals that the flux density is decreasing by about 1 per cent per annum. Similar measurements are also in progress at the U.S. National Radio Astronomy Observatory, Green Bank (J. Findlay, private communication), at a frequency of 1,420 Mc./s.

Absolute measurements of flux density are not easy, but fortunately the flux density of Cassiopeia A (at α = 23h. 21m., δ = + 58° 32′) may readily be compared with that of Cygnus A (at α = 19h. 58m., δ = + 40° 36′), since these sources are the strongest two at metre wave-lengths and are not far distant from one another in the sky. Cygnus A has been identified with a pair of colliding galaxies and its flux density is not likely to change appreciably in a time small compared with that taken by radio waves to traverse the source itself—say 10^5 years.

The same aerial[3] has been used for all the observations, which have been at a frequency of 81·5 Mc./s. It is a fixed transit instrument consisting of two broadside arrays, each measuring 10 × 1 wave-lengths, separated by 100 wave-lengths on an east–west axis. The reception pattern of each aerial is therefore restricted to ± 3° in an east–west plane, but covers about ± 45° in the north–south plane. There are three sets of observations, one in December 1948 and January 1949, one in November 1956 and one in December 1960. The receiver used for the first two series was a total-power receiver of the type developed by Machin, Ryle and Vonberg[4] and for the third series, a phase-switching receiver[5]. In each case, records showing obvious signs of scintillations have been discarded, leaving records of 14, 10 and 13 days, respectively.

Table 1

Date	Mean ratio of observed record amplitudes Cassiopeia A/Cygnus A	Standard error of mean
December 1948 / January 1949	1·751	± 0·024
November 1956	1·635	± 0·019
December 1960	1·536	± 0·017

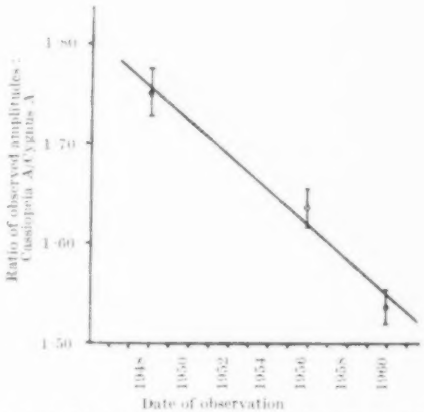


Fig. 1. A plot of the mean ratios of observed amplitudes of records of the radio sources Cassiopeia A and Cygnus A as a function of time. The vertical lines indicate standard errors

Table 1 gives the averages of the ratios of observed record amplitudes of Cassiopeia A and Cygnus A for the three sets of observations and in Fig. 1 they are plotted against the dates of the observations. The standard errors of the averages of the ratios are indicated on the plot. It should be noted that the ratios have *not* been corrected for the aerial polar diagram.

Unless some unknown systematic error varying with time is involved, there is very strong evidence for a change in the relative flux densities of Cassiopeia A and Cygnus A. If it is assumed that the flux density of the latter source has remained constant, then a least-squares solution for the best straight line through the points indicates a decrease in the flux density of Cassiopeia A of (1·06 ± 0·14) per cent per annum.

A number of possible sources of error are eliminated by the use of the same aerial system for all the observations. Some others that have been considered include non-linearity of the receivers, effects of a variation of output time constant (since the periodicities of the interference fringes of Cygnus A and Cassiopeia A differ) and changes in the polar diagram of the arrays. None is thought to be sufficient to account for the observed change of ratio. The effect of the increase of the angular size of the Cassiopeia A source with time is quite negligible.

Shklovsky[6], assuming that the radio radiation is due to the synchrotron mechanism, has made a theoretical prediction that the present yearly fractional change of the flux density of Cassiopeia A is:

$$\frac{\Delta S_\nu}{S_\nu} = \frac{3}{\text{age in years}}$$

where $\beta = 2(1 + 2\alpha)$ and α, the spectral index, is given by : $S_\nu \propto \nu^{-\alpha}$. If $\alpha = 0{\cdot}8$ and the age is 258 yr., then :

$$\frac{\Delta S_\nu}{S_\nu} \simeq -2 \text{ per cent}$$

which is remarkably close to the observed figure. Some of his assumptions are debatable and it would not seem difficult to modify them to obtain an even closer agreement. Shklovsky's argument involves a constant energy spectrum for fast electrons and a magnetic field inversely proportional to the square of the nebular radius. This implies that the fractional change will be independent of frequency, as seen above, since β for Cassiopeia A is independent of frequency[7]. It will be interesting to see if observations at other frequencies confirm this.

In conclusion, the obvious point must be made that Cassiopeia A should no longer be considered as a standard source for the measurement of flux densities.

We thank Prof. M. Ryle for the loan of the records taken during the period December 1948–January 1949.

J. A. HÖGBOM*
J. R. SHAKESHAFT

Mullard Radio Astronomy Observatory,
Cavendish Laboratory,
Cambridge.

* At present at Sterrewacht, Leyden, The Netherlands.

[1] Ryle, M., and Elsmore, B., *Nature*, **168**, 555 (1951).
[2] Minkowski, R., *Paris Symposium on Radio Astronomy*, 315, edit. by Bracewell, R. N. (Stanford Univ. Press, 1959).
[3] Ryle, M., Smith, F. G., and Elsmore, B., *Mon. Not. Roy. Astro. Soc.*, **110**, 508 (1950).
[4] Machin, K. E., Ryle, M., and Vonberg, D. D., *Proc. Inst. Elect. Eng.*, Part 3, **99**, 127 (1952).
[5] Ryle, M., *Proc. Roy. Soc.*, A, **221**, 351 (1952).
[6] Shklovsky, I. S., *Astro. Zhur.*, **37**, 256 (1960).
[7] Whitfield, G. R., *Mon. Not. Roy. Astro. Soc.*, **117**, 680 (1957).

RADIOPHYSICS

A New Method for the Calculation of $N(h)$ Profiles from Ionospheric $h'(f)$ Curves

RECENTLY[1–4], a lamination method has been developed for the calculation of electron density-height profiles ($N(h)$ profiles) from ionospheric virtual height-frequency curves ($h'(f)$ curves) with an electronic digital computer.

This method includes the evaluation of integrals of the 'group refractive index' μ' of the radio waves in the ionosphere. Generally, μ' is related to the (phase) refractive index μ through the equation :

$$\mu' = \mathrm{d}(f\mu)/\mathrm{d}f \qquad (1)$$

where μ' and μ are functions of the frequency f of the wave and the electron density $N(h)$ in the ionosphere, which is a function of the height h above ground.

According to the magneto-ionic theory, μ is given, under the influence of the Earth's magnetic field $\mathbf{H}_0$, by the Appleton–Hartree formula as[5] :

$$\mu^2 = 1 - \frac{X}{1 - \frac{1}{2}Y_T^2/(1 - X) + [Y_T^4/4(1 - X)^2 + Y_L^2]^{1/2}} \qquad (2)$$

for the ordinary wave, where

$X = f_N^2/f^2$, $Y = f_H/f$, $Y_T = Y \sin\theta$, $Y_L = Y \cos\theta$, and θ is the angle between the wave normal and $\mathbf{H}_0$. ($|\mathbf{H}_0| = H_0$).

$f_H (= e\mu_0 H_0/2\pi m)$ and $f_N (= [Ne^2/m\varepsilon_0]^{1/2}/2\pi)$ are the gyro-frequency of an electron and the plasma frequency in the ionosphere in M.K.S. units.

An ionospheric $h'(f)$ curve for the ordinary wave is given by :

$$h'(f) = \int_0^{h_r} \mu'(f, f_0(h))\mathrm{d}h \qquad (3)$$

where $f_0(h)$ is used instead of $N(h)$ in μ', and h_r denotes the level where the wave is reflected, $f_0(h_r) = f$.

Assuming that $f_0(h)$ is a monotonic function of h, equation (3) becomes :

$$h'(f) - h_0 = \int_0^f \mu'(f, f_0)(\mathrm{d}h(f_0)/\mathrm{d}f_0)\mathrm{d}f_0, \; 0 \leqslant f_0 \leqslant f \qquad (4)$$

h_0 is the level where $f_0(h_0) = 0$, or $N(h_0) = 0$.

Equation (4) is the starting-point of the lamination method[1].

Since formula (2) for μ is rather complicated and μ' is related to μ by equation (1), the evaluation of integrals of μ' seems, even by the use of an electronic computer, very elaborate[4].

To avoid this difficulty, I have devised an improved method for the calculation of $N(h)$ profiles.

Integrating both sides of equation (4) with respect to f, over the range of $0 \leqslant f \leqslant f_1$:

$$\int_0^{f_1}[h'(f) - h_0]\mathrm{d}f = \int_0^{f_1}\mathrm{d}f \int_0^f \mu'(f, f_0)(\mathrm{d}h(f_0)/\mathrm{d}f_0)\mathrm{d}f_0 \qquad (5)$$

and changing the order of integration in the right side of equation (5) :

$$= \int_0^{f_1}\mathrm{d}f_0(\mathrm{d}h(f_0)/\mathrm{d}f_0)\int_{f_0}^{f_1}\mu'(f, f_0)\mathrm{d}f$$

According to equation (1), the integral in the above expression is :

$$\int_{f_0}^{f_1}\mu'(f, f_0)\mathrm{d}f = f\mu(f, f_0)\Big|_{f_0}^{f_1} = f_1\mu(f_1, f_0) - f_0\mu(f_0, f_0)$$

Since $\mu(f_0, f_0) = 0$ by equation (2), equation (5) reduces to :

$$\frac{1}{f_1}\int_0^{f_1}[h'(f) - h_0]\mathrm{d}f = \int_0^{f_1}(\mathrm{d}h(f_0)/\mathrm{d}f_0)\mu(f_1, f_0)\mathrm{d}f_0$$

Or, putting

$$\frac{1}{f_1}\int_0^{f_1}h'(f)\mathrm{d}f = g(f_1), \text{ and } f_1 \to f,$$

we obtain :

$$g(f) - h_0 = \int_0^f (\mathrm{d}h(f_0)/\mathrm{d}f_0)\mu(f, f_0)\mathrm{d}f_0 \qquad (6)$$

where $g(f_1)$ is then the average of $h'(f)$ within $0 \leqslant f \leqslant f_1$.

Equation (6) is equivalent to equation (4) and can be used for the calculation of $N(h)$ profiles after the same manner as the above-mentioned lamination or matrix method[1]; but equation (6) contains the integral of μ instead of μ' in equation (4), so the programming for an electronic computer by equation (6) will be, we believe, much easier than that of equation (4).

It should be noted that this method can also be used for the $h'(f)$ curve of the extraordinary wave.

Furthermore, as f approaches critical frequency f_c, the virtual height $h'(f)$ tends to increase infinitely and $h'(f_c)$ is often indefinite; but, if :

$$g(f_c) = \lim_{f_1 \to f_c}(1/f_1)\int_0^{f_1}h'(f)\mathrm{d}f$$

converges, the height of maximum electron density $h(f_c)$ can be determined by equation (6).

Physically speaking, if the $N(h)$ profile has a definite maximum point, $g(f_c)$ will converge; and vice versa.

μ' has the property that $\mu'(f_o, f_o) \to \infty$, but $\mu(f_o, f_o) = 0$; and this may be related to the properties of $h'(f_c)$ and $g(f_c)$. For example, if an approximation of $h'(f) \doteqdot A/(f_c - f)^m$ is valid near the critical frequency f_c, where A and m are constants greater than 0, $g(f_c)$ converges if $1 > m \geqslant 0$, but $h'(f_c)$ tends to infinity.

Since $g(f)$ in equation (6) should be a monotonic function of f, $h'(f)$ should also be monotonic: therefore, this method cannot be applied for an $N(h)$ profile which has a 'valley' in the electron density.

The scaling error ε of the $h'(f)$ curve would be given by:

$$\varepsilon = h'(f)_{\text{scaled}} - h'(f)_{\text{true}} = \delta h' + (\mathrm{d}h'(f)/\mathrm{d}f)\delta f \qquad (7)$$

where $\delta h'$ and δf are the height and frequency errors which are proper to the quality of the $h'(f)$ record, and are considered to be random variables.

Simpson's numerical integration method[4] will be adequate for the calculation of $g(f)$ from the scaled values of $h'(f)$, and if a sufficiently large number of n-points (including the value of h_o) are scaled from an $h'(f)$ record between $f = 0$ and $f = f_1$ near f_c, the relative error of $g(f)$ will decrease proportionally to the inverse square root of n. On the other hand, the $h'(f)$ curve then can be represented, for example, through the Lagrangian interpolation formula[5], by a polynomial of degree $(n - 1)$, passing through these n-points, by:

$$h'(f) = \sum_{m=0}^{n-1} a_m f^m, \quad 0 \leqslant f \leqslant f_1 \qquad (8)$$

Then:

$$g(f) = \sum_{m=0}^{n-1} a_m f^m/(m + 1)$$

so the component of degree m in $g(f)$ is diminished by a factor of $1/(m + 1)$, which is of higher order than the factor $1/n^{1/2}$ of the relative scaling error of $g(f)$.

This defect, however, seems to be offset by the property of $g(f)$, which is rather insensible to the possible large scaling error of the $h'(f)$ record near the critical frequency f_c owing to a large value of $\mathrm{d}h'(f)/\mathrm{d}f$ in equation (7); and the behaviour of $h'(f)$ near f_c is, probably, responsible for the terms of higher degrees in equation (8).

Further details of this work will be reported elsewhere.

H. Hojo

Radio Research Laboratories,
Kokubunji P.O., Koganei-shi,
Tokyo.

[1] Budden, K. G. A., Rep. Camb. Conf. Ionosph. Phys. (Phys. Soc., Lond.), 332 (1954).
[2] Schmerling, E. R., Penn. State Univ. Ionosph. Res. Sci. Rep., No. 94 (1957).
[3] Thomas, J. O., Haselgrove, J., and Robbins, A. R., *J. Atmos. Terr. Phys.*, **12**, 46 (1958).
[4] Thomas, J. O., and Vickers, M. D., Dept. Sci. Indust. Res. Radio Res. Spec. Rep. No. 28 (1959).
[5] Ratcliffe, J. A., "The Magneto-Ionic Theory and its Application to the Ionosphere", 18 (Camb. Univ. Press, London, 1959).
[6] Nielsen, K. L., "Methods in Numerical Analysis", 119 and 138 (Macmillan Co., New York, 1956).

PHYSICS

Influence of an Electric Field upon the Heat Transfer from a Hot Wire to an Insulating Liquid

If a non-uniform electric field is applied to a medium of dielectric constant K_1, containing a region of lower dielectric constant K_2, the latter will experience a force directed towards the region of lower field strength. This force is proportional to the difference between the two dielectric constants and the gradient of the square of the electric field. Now, when a liquid is heated, and expands, there is a resultant fall in dielectric constant, so that if the heating occurs in a region of high field, the heated liquid should be forced into regions of lower field strength.

In a recent experiment, we have been able to show that this effect can be used for enhancing the rate of heat transfer between a heated wire and an insulating liquid in which the wire is immersed.

The apparatus consists of a coaxial cell, in which the hot wire, which is at ground potential, is surrounded by a cylindrical electrode, to which the high voltage is applied. Measurements of the current flowing through the wire and the voltage drop along it are used for determining both the temperature of the wire and the power input. Under equilibrium conditions (attained in a few seconds), the heat input to the wire becomes identical to the heat transferred from the wire to the liquid.

The results given in Fig. 1 were obtained using hexane as the working fluid; the central electrode was a 0·1-mm. diameter nickel wire, and the outer electrode was a 3-cm. diameter nickel cylinder, 10 cm. in length.

In Fig. 1, the upper curve corresponds to conditions of zero applied field, and shows the loss of heat from the horizontal wire due to natural convection;

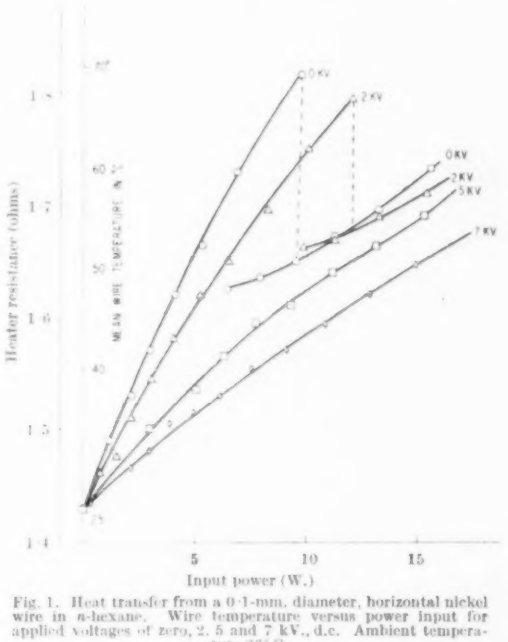


Fig. 1. Heat transfer from a 0·1-mm. diameter, horizontal nickel wire in *n*-hexane. Wire temperature versus power input for applied voltages of zero, 2, 5 and 7 kV., d.c. Ambient temperature 26° C.

the sudden break in the curve, at a power input of about 10 W., corresponds to the onset of boiling.

When a d.c. potential of a few kV. was applied between the wire and the cylinder, there was a fall in the temperature of the wire, as can be seen from the curves (Fig. 1), indicating a considerable enhancement of the heat transfer coefficient. (For example, below the region of boiling heat transfer, in going from zero to 5 kV., the mean temperature rise of the wire was approximately halved, indicating a doubling of the heat transfer coefficient.)

It is interesting to note that in the region of boiling heat transfer, bubbling of the liquid around the wire could be suppressed by application of the field; as can be seen from Fig. 1, this results in a decrease in heat transfer coefficient in going from zero to 2 kV.—though this effect is restricted to the immediate vicinity of the onset of boiling.

The results shown in Fig. 1 were obtained with a positive applied high voltage, but virtually identical results were found with a negative voltage. This observation is consistent with the initial assumption that the effect is an electrostatic one, and shows that the interactions between the electrostatic field and ions in the liquid play a negligible part in this phenomenon.

P. Keith Watson

General Electric Research Laboratory,
Schenectady,
New York.

Electron Microscopy of Crystal Lattices: an Anomalous Effect

An explanation of intensity modulations in electron micrographs of crystal lattices[1] has recently been given by Labaw[2], and Hashimoto, Naiki and Mannami[3] have published a theoretical interpretation of fringe separation modifications which occur when a Bragg extinction contour lies in the same direction as the crystal 'lattice planes' resolved. The present communication deals with the conditions which exist when a Bragg extinction contour lies across the lattice planes in question. A theory given by Cowley and Moodie[4] is used to interpret a phenomenon which has recently been observed in practice (see Fig. 1).

Two strong beams only, the incident and one diffracted beam, are considered to have amplitudes U_0 and U_h respectively in the crystal. Then:

$$U_0 = [\cos\omega H - i(\pi\zeta_h/\omega)\sin\omega H]\exp\{i\sigma HE_0 - \varrho HG_0 + \pi i\zeta_h H\} \quad (1)$$

$$U_h = iF_h(\sin\omega H/\omega)\exp\{i\sigma HE_0 - \varrho HG_0 - \pi i\zeta_h H\} \quad (2)$$

where F_h is a structure factor:

$$F_h = \sigma E_h + i\varrho G_h$$

and:

$$\omega = (\pi^2\zeta_h^2 + F_hF_{\bar{h}})^{1/2} \qquad \text{(see ref. 4b)}$$

In these equations, H is the crystal thickness and ζ_h is a factor representing the deviation from the Bragg angle, being the separation between the sphere of reflexion and the reciprocal lattice point given by h. In the Bethe[5] terminology, ζ_h is called the excitation error.

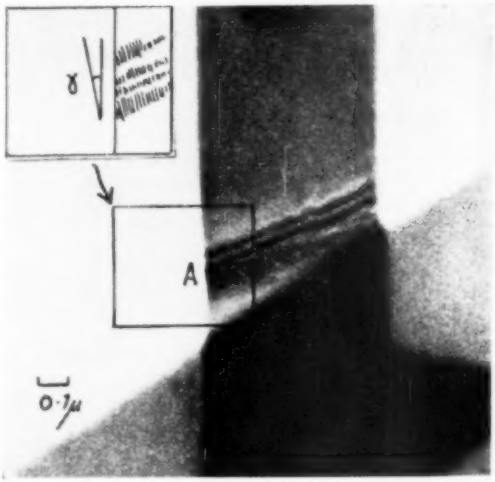


Fig. 1. Electron micrograph of a crystal of platinum phthalocyanine overlying a second crystal. 201 fringes are resolved at A on the Bragg extinction contours. The inset is a diagrammatic representation of the area marked

Equations (1) and (2) enable one to obtain the intensity distribution at the exit face of the crystal:

$$\psi\psi^* = |U_0 + U_h\exp\{-2\pi ihx/a\}|^2$$

that is,

$$\psi\psi^* = 1 - 2|F_h|\frac{\sin\omega H}{\omega}\left(\cos^2\omega H - \frac{\pi^2\zeta_h^2}{\omega^2}\sin^2\omega H\right)\cos 2\pi\left(\frac{hx}{a} - \zeta_h H - \gamma\right) \quad (3)$$

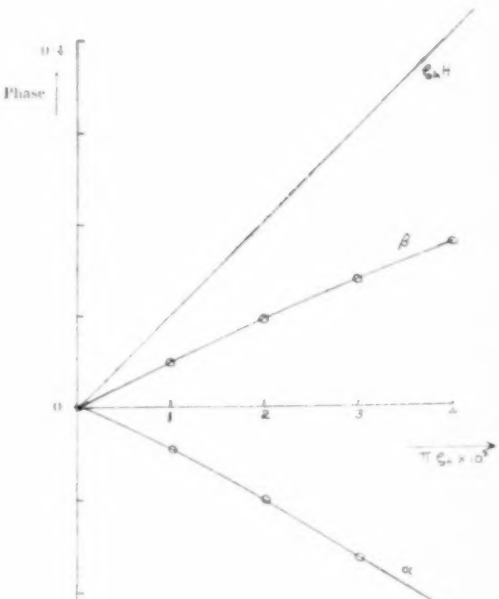


Fig. 2. Graph to show the relationships between α, β, $\zeta_h H$ and ζ_h for values of ζ_h up to $\frac{4}{\pi} \times 10^{-3}$. $F_hH = \pi/2$ and $H = 2000$ Å.

and then :

$$2\pi z = \tan^{-1}\left\{\frac{\sigma E_h \cos\omega H - (\pi\zeta_h/\omega)\rho G_h \sin\omega H}{\rho G_h \cos\omega H + (\pi\zeta_h/\omega)\sigma E_h \sin\omega H}\right\} \quad (4)$$

Of importance in equation (3) is the cosine term in x and the associated phase factor $\beta = (\zeta_h H - \alpha)$. The cosine term gives rise to the periodic undulations of intensity which are made visible when a microdensitometer, for example, is made to scan across several fringes. The phase term β, however, can in some circumstances lead to an anomalous effect, where the fringes lie at a considerable angle γ to the true lattice plane direction. In Fig. 1, the fringes at A make an angle of $\gamma \sim 8'$ with the parallel sides of the crystal. This effect can be predicted theoretically with the two-beam theory if representative values are chosen for H and F_h (see ref. 4*b*) and calculations of z and β made for specific values of excitation error ζ_h. Fig. 2 shows the results of such a calculation. The effect of adding the z curve to the $\zeta_h H$ line certainly leads to a β curve of reduced slope, but the graphs do not mutually cancel. The fact that the final curve has a finite slope implies a continuously changing phase factor as the excitation error increases to a value of $4\pi \times 10^{-3}$ and, in this range, this must necessarily mean that the fringes are not parallel with the crystal sides.

It is to be concluded that, although fringe spacings in a perfect crystal are indicative of the actual separations of molecular planes[6], both the separation and the direction of fringes at or near a Bragg extinction contour must be treated with reserve.

I thank Dr. F. P. Bowden for help and encouragement, Drs. J. W. Menter, V. E. Cosslett and M. J. Whelan for discussion, and Imperial Chemical Industries, Ltd., for crystal specimens.

LEWIS T. CHADDERTON

Physics and Chemistry of Solids,
Cavendish Laboratory,
Cambridge.

[1] Menter, J. W., *Proc. Roy. Soc.*, A, **236**, 119 (1956); *Phil. Mag.*, Supp., **7**, 27, 299 (1958).
[2] Labaw, L. W., *Proc. Electron Microscope Soc. Amer.* (August 1960).
[3] Hashimoto, H., Naiki, I., and Mannami, M., *Proc. Fourth Int. Conf. Electron Microscopy, Berlin* (September 1958).
[4] (*a*) Cowley, J. M., and Moodie, A. F., *Acta Cryst.*, **10**, 609 (1957). (*b*) Cowley, J. M., *Acta Cryst.*, **12**, 367 (1959).
[5] Bethe, H. A., *Ann. Phys.*, **87**, 55 (1928).
[6] Chadderton, L. T., *Nature*, **186**, 541 (1960); *Proc. European Regional Conf. Electron Microscopy*, Delft (September 1960).

Magnetic Energy

I WOULD like to comment, if rather tardily, on one paragraph of Prof. Ferraro's review[1] of my book, *Electromagnetism and Relativity*[2]. He says : "Prof. Cullwick appears to be under a misapprehension about the nature of the magnetic energy of a system of electric currents . . . we read that 'the hypothesis is introduced that the magnetic energy of a current circuit is the same as the kinetic energy of the effective conduction electrons, by virtue of their mean velocity along the wire'. The author then derives from this hypothesis a linear relation between the magnetic vector potential and the mean velocity of the charges . . . the hypothesis appears to be rather misleading. It is used in the chapter on superconductors to derive the familiar equations due to F. and H. London. Here the application is legitimate and indeed the linear relation mentioned above was first derived in connexion with the phenomenological theory of superconductors. But the relation cannot be universally true since it would seem to carry with it the implication that all conductors are superconductors".

From this, it would appear that Prof. Ferraro regards my hypothesis as leading to a macroscopic theory of superconductors identical with that of F. and H. London. This is not so. The hypothesis is that the magnetic energy of a quasi-steady conduction current is *in fact* the kinetic energy of all the conduction electrons which happen to be current carriers (that is, contributing to the macroscopic magnetic field) at a given instant, the effective electronic mass, m, including both the intrinsic mass and the mutual mass corresponding to the mutual electrokinetic energy of the electron with all the other effective conduction electrons in the circuit. The effective mass m will therefore depend on the configuration of the circuit, as does the coefficient of self-inductance, and will not have a constant value across the section of a finite conductor. If $\mathbf{A}$ is the component of the total vector potential due to the current in the single circuit considered, the hypothesis is, in general, summed up in the equation :

$$m v = e A, \quad (1)$$

so that in cases in which A and v are parallel :

$$m \mathbf{v} = e \mathbf{A} \quad (2)$$

(In the first edition of my book equation (2) was used, incorrectly, in place of equation (1), which will be found in the second edition, p. 247.)

This is not part of the London theory of superconductors. The latter gives, for conductors large compared with the depth of penetration of the supercurrent, equality between the kinetic energy density of the supercurrent and the energy density of the magnetic field[3] ; but these energies are regarded as separate and additive. For stationary conditions in an isolated singly connected superconductor, the London theory gives :

$$m \mathbf{v} = -e \mathbf{A} \quad (3)$$

where $\mathbf{A}$ is the total vector potential and m the intrinsic electronic mass, which is not the same as equation (2).

In order to prevent further misunderstanding it is, I think, relevant to add some general comments.

(*a*) The magnetic energy of a current is a physical reality, not merely a mathematical fiction. Maxwell's general view of it has never been contested : "since we can form no conception of an electric current except as a kinetic phenomenon, its energy must be kinetic energy, that is to say, the energy which a moving body has in virtue of its motion. . . . We are therefore led to inquire whether there may not be some motion going on in the space outside the wire, which is not occupied by the electric current, but in which the electromagnetic effects of the current are manifested"[4*a*].

(*b*) Maxwell regarded magnetic energy as kinetic energy in the universal medium or æther : "According to our hypothesis, we assume the kinetic energy to exist wherever there is magnetic force, that is, in general, in every part of the field . . . and this energy exists in the form of some kind of motion of the matter in every portion of space"[4*b*].

(*c*) H. A. Lorentz's modification of Maxwell's theory, which when combined with the Lorentz transformation is universally accepted to-day, involves an immobile æther which is therefore incapable, by itself, of possessing kinetic energy. The theory retains, however, Maxwell's original assumption that an electric current *per se* has no inertia, an assumption since proved by experiment to be incorrect.

(*d*) One may then legitimately ask, of those who reject my hypothesis: "What *is* magnetic energy?".

(*e*) Since an electron can be transformed, by collision with a positron, into electromagnetic radiation, it is reasonable to take its mass as being entirely electromagnetic, although as yet the only microscopic explanation of this is the unsatisfactory one in which classical theory is applied to the external field of a billiard-ball model.

(*f*) In modern theories of conduction the electron is treated in an over-simplified way. It is electrically charged, it is true, but its magnetic properties are largely ignored (an exception is L. Brillouin, *Helv. Phys. Acta*, **7** (Supp.), 47 (1934)). Its kinetic energy is somehow regarded as 'mechanical'. The logical deduction from this is that, when free electrons are accelerated in a vacuum to high energies, their kinetic energy eV is mechanical not magnetic, so that, contrary to all accepted theory, moving charges do not cause a magnetic field.

(*g*) If two electrons, macroscopically coincident, are moving in opposite directions with equal velocities, they cause no resultant macroscopic magnetic field. In a conductor carrying no current it is accepted, in modern theories, that the conduction electrons have random velocities with a Fermi-level of the order of 10^6 metres per sec. When an electric field is applied, almost all the conduction electrons continue to have paired velocities so that their macroscopic magnetic field is nil, but an extremely small proportion attain energies which are not balanced by electrons moving in the opposite direction. The macroscopic magnetic field must therefore be due to this very small proportion of electrons, moving with high velocities.

(*h*) The mechanism, possibly quantized, whereby an applied electric field imparts energy to the conduction electrons is unknown, and the hypothesis, based on a free electron gas, that every conduction electron has its energy changed by a small amount according to classical mechanics may well be entirely wrong. I have shown that if the magnetic field is due to a very small proportion of the available conduction electrons, moving with high velocities, their kinetic energy, even if m is taken to be equal to m_0, is of the same order of magnitude as the magnetic energy in typical current circuits.

(*i*) In my hypothesis the mass of a conduction electron is not to be considered as being limited to the 'particle'. It is the electron's share of the mass of the total electromagnetic energy, both internal and external, of all the current-carrying electrons in the circuit, and must be regarded as extending throughout the electromagnetic field. It thus satisfies Maxwell's 'general hypothesis' quoted in (*a*) above. If the current is steady, this electromagnetic energy is considered to move with the same mean velocity as the electrons. There is no universal material medium through which electromagnetic energy can move only with the speed of light; but when the current changes, then the consequent disturbance of the steady conditions is communicated to a distant element of the field with the velocity of radiation.

E. G. Cullwick

Queen's College,
University of St. Andrews,
Dundee.

Nature, **182**, 1045 (1958).
[2] Longmans, Green and Co. (1957); second ed. (1959).
[3] London, F., *Superfluids*, **1**, 66 (Wiley, New York, 1950).
[4] (*a*) Maxwell, J. C., *A Treatise on Electricity and Magnetism*, **2**, §552 (third ed., 1892); (*b*) *ibid.*, §636.

Prof. Cullwick has directed attention to an incorrect statement, which I regret, in my review of the first edition of his book *Electromagnetism and Relativity*. As he says, the fundamental relation derived from his hypothesis (equation (1) of his communication) differs in sign from that usually adopted in the theory of superconductors so that Prof. Cullwick's hypothesis cannot be identified with the former—contrary to my statement.

My error, however in no way invalidates my contention that Prof. Cullwick's hypothesis is misleading. In the first instance, the relation $m\mathbf{v} = e\mathbf{A}$ is itself misleading, since it implies that the mean velocity of the conduction electrons is in all cases in the direction of the local vector potential. This is certainly not true, and in the second edition of his book the author has modified this relation in an attempt to overcome its shortcomings. Secondly, and this was my main contention, the hypothesis is misleading since in no sense can the magnetic energy be identified with the kinetic energy of the effective conduction electrons. In fact, the former is field energy propagated with the speed of light, and so cannot be identified with mechanical energy of the motion of the electrons. In any event, I cannot see what useful purpose such an identification would serve. In Maxwell's dynamical theory of electric currents a useful formalism is developed along the lines of Lagrange's analytical dynamics in which the magnetic energy of the electric current is shown to be the 'analogue' of the kinetic energy in a mechanical system. There is no implication that the two forms of energy are of the same nature. (In fact, Maxwell took care to call the energy of the currents 'electrokinetic' energy.) Any attempt to make it so appears to be a retrograde step, since most of the inertia associated with a system of currents is of electromagnetic origin. The artificiality of this hypothesis becomes, moreover, apparent when one considers that the definition of the inertia of the conduction electron would depend on the particular distribution of currents and on the position of the electron at any instant—surely a curious result.

V. C. A. Ferraro

Queen Mary College,
London, E.1.

METALLURGY

Some Properties of Scandium Metal

Scandium is one of the metals being used in an investigation into the alloying behaviour of plutonium with the metals of Group III which is being conducted at this Establishment. Since there is only limited published information on the properties of scandium itself, some experiments were undertaken on the

metal. Recently, Spedding *et al.*[1] have reported some work with which the present results are in general agreement.

Thermal analysis, electrical resistance and X-ray diffraction techniques were employed for examination of the behaviour of the metal between room temperature and its melting point. The scandium was of reasonable purity, the main impurities being tantalum $\leqslant 0{\cdot}1$ wt. per cent, copper $\leqslant 200$ p.p.m., silver $\leqslant 100$ p.p.m., iron $\leqslant 20$ p.p.m. and combined rare earths $\leqslant 100$ p.p.m.

For thermal analysis measurements, a platinum-wound furnace was used and was filled with nitrogen at a pressure of 1/3 atm. to prevent volatilization of the scandium at high temperatures. A measuring platinum/platinum–rhodium thermocouple in a closed alumina sheath was in contact with approximately 1 gm. of scandium in a tantalum crucible. During initial runs, the metal when molten attacked the alumina, and a thin tantalum sheath was therefore placed over the end of the alumina for subsequent runs; at this point, the original scandium was replaced by a fresh specimen.

Thermal analysis arrests were invariably weak; but the observed melting point was cross-checked by noting the temperature at which the sheathed thermocouple could be pushed into the scandium during the initial run. The average value obtained for the melting point was $1{,}522 \pm 5°$ C. However, an analytical check (Phillips, G., and Birks, F. T., private communication) showed that the sample had picked up an appreciable amount of tantalum, in agreement with an observation by Spedding[1]; nevertheless the value obtained does not differ greatly from that of $1{,}539 \pm 2°$ C. observed by Spedding. A second arrest was observed at $1{,}373 \pm 10°$ C., which may correspond to one observed at 1,335° C. by the American workers (Spedding, F. H., private communication). Owing to the high transition temperature, it was not possible to determine the crystal structure of the high-temperature modification with the available powder camera, but by analogy with certain of the rare earth elements it might be expected to be body-centred cubic[2].

The initial runs, in which an unprotected alumina sheath was used for the thermocouple, gave a value of about 1,490° C. for the melting point, suggesting that aluminium lowers the melting point of scandium.

Electrical resistance measurements were carried out on a short length of 0·040 in. diameter wire, which had been extruded using a pressure of 10 tons/sq. in. at 600° C. Current and potential leads were provided by spot welding 0·020 in. diameter platinum wires to the sample. The wire was then mounted in a vacuum furnace and the resistance recorded continuously as the temperature was raised; the method used has been described elsewhere[3].

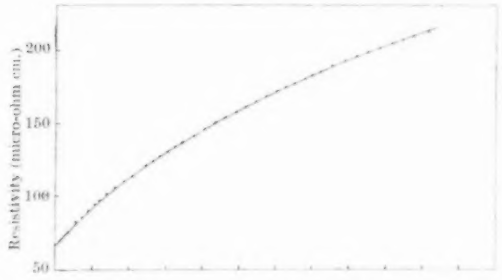


Fig. 1. Electrical resistivity-temperature curve for scandium

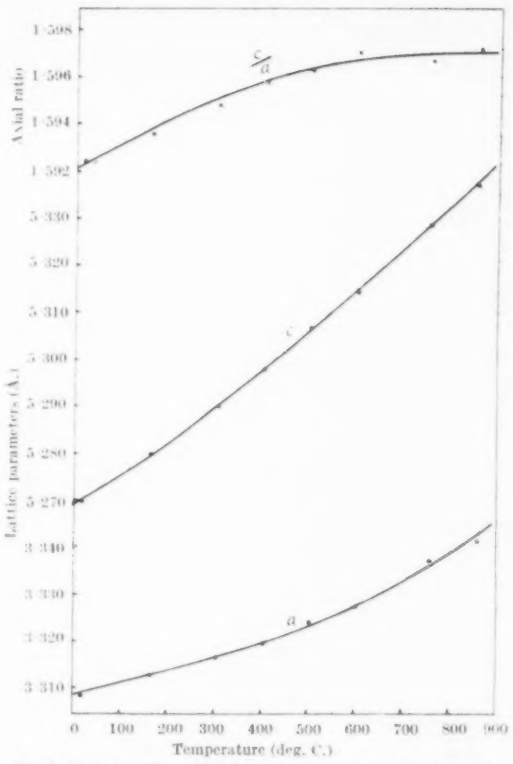


Fig. 2. Variation of scandium lattice parameters with temperature

During successive cycles measurements were taken to steadily higher temperatures; in the final cycle, the electrical contact failed at 1,160° C. On demounting the specimen it appeared that the failure was due to the formation of a low melting-point alloy at the contact points, implying that platinum markedly reduces the melting point of scandium. The resistance measurements at temperatures between 1,050° C. and 1,160° C. were variable, probably due to alloying, and the results shown in Fig. 1 have therefore been cut off at 1,050° C. There is no sign of any phase change taking place in the temperature-range 40–1,050° C., which is in agreement with the thermal analysis data. The 25° C. value of the resistivity was 72 micro-ohm cm., which is much greater than that of the common metals but is in reasonable accordance with the values for the rare earths, most of which lie in the range 55–75 micro-ohm cm. at 25° C.[2]. Previous investigators have given a figure of 66·6 micro-ohm cm. for the resistivity of scandium at 25° C.[1].

The temperature coefficient of resistivity decreases as the temperature is raised, the corresponding values being $3{\cdot}7 \times 10^{-3}$ at 100° C., $2{\cdot}1 \times 10^{-3}$ at 500° C., and $1{\cdot}3 \times 10^{-3}\ \Omega/\Omega$ —° C. at 900° C.

An attempt was made to determine the thermal conductivity of the wire using Kannaluik's method, but in practice the contact wires were not sufficiently massive to keep the temperature of the ends of the specimen down to ambient temperature as required

by Kannaluik. An estimate can be made of the thermal conductivity by using the Weidemann–Franz relationship, since it is probable that the Lorenz ratio for scandium is similar to that of the early members of the rare earth series, that is, around $2{\cdot}7 \times 10^{-8}$ e.g.s. units. On this basis, the thermal conductivity of scandium would be 0·027 cal. cm./cm.^{2} sec. deg. C., at room temperature.

In the X-ray diffraction studies, using a 19-cm. high-temperature powder camera, scandium was examined at temperatures up to 850° C. The filings had been sealed in a thin-walled silica tube under vacuum but even so at a temperature of 750° C. the lines of scandium oxide appeared on the film. No attempt was made to take photographs above 850° C. because of the limitations of furnace power and the rapidly increasing strength of the oxide lines.

The structure remained hexagonal close-packed throughout the temperature range employed. The values of the lattice parameters and of the axial ratio are shown in Fig. 2; the behaviour is very similar to that of many of the rare earths[2], the c parameter increasing more rapidly than the a parameter at low temperatures, while at high temperatures the rate of increase of the parameters is comparable so that the axial ratio becomes approximately constant. A least-squares fitting of the experimental points gives the following values for the instantaneous coefficients of thermal expansion:

$$\alpha = (5{\cdot}6_5 + 1{\cdot}3_7 t).10^{-6}/°\,\text{C.}$$

$$c = (12{\cdot}7_3 + 0{\cdot}5_7 t).10^{-6}/°\,\text{C.}$$

where t is the temperature (deg. C.). Thus the values for temperatures of 100° C., 500° C., and 800° C. are 7·1, 12·5 and $16{\cdot}6 \times 10^{-6}$/deg. C., for α_a and 13·3, 15·6 and $17{\cdot}3 \times 10^{-6}$/deg. C. for α_c.

P. G. Mardon
J. L. Nichols
J. H. Pearce
D. M. Poole

Plutonium Metallurgy Group,
Atomic Energy Research Establishment,
Harwell.

[1] Spedding, F. H., Deane, A. M., Wakefield, G., and Dennison, D. H., *Trans. Met. Soc. A.I.M.E.*, **218** (4), 608 (1960).
[2] Gschneidner, jun., K. A., *A Compilation of the Physical Properties of the Rare Earth, Scandium and Yttrium Metals* (to be published).
[3] Hull, J. G., Lee, J. A., Mardon, P. G., and Robertson, J. A. L., *Mem. Sci. de Rev. de Met.*, **57**, 1, 43 (1960).

Control of Irradiation Embrittlement in Molybdenum

Irons, steel, and other body-centred cubic metals show an increase in ductile-brittle transition temperature as a result of neutron irradiation. In an attempt to elucidate the mechanism of this embrittlement for *EN2* steel, Hull and Mogford[1] studied the effect of neutron irradiation on the parameters σ_i and k_y in the Petch relation:

$$\sigma_y = \sigma_i + k_y d^{-1/2} \qquad (1)$$

where σ_y is the yield stress and $2d$ the grain diameter. They found that σ_i, the lattice friction stress, increased, but k_y, which is a measure of the strength of dislocation locking, remained constant. They interpreted this to mean that the embrittlement was caused by point defects or groups of defects which impeded the movement of slip dislocations in their glide planes. This simple phenomenological description of irradiation embrittlement enables changes in ductile-brittle transition temperature caused by irradiation to be predicted from Cottrell's brittle fracture criterion[2]:

$$(\sigma_i d^{1/2} + k_y) k_y \geqslant \beta \mu \gamma \qquad (2)$$

once σ_i has been measured as a function of integrated neutron flux.

Johnson[3] has applied a similar method to that of Hull and Mogford in studying the irradiation embrittlement of molybdenum. His results showed that the embrittlement mechanism in molybdenum is more complex than for *EN2* steel, and in interpreting his results Johnson suggested that in pure metals the point defects created during irradiation cause dislocation climb. It follows that the effect of irradiation on the mechanical properties of a pure metal such as molybdenum should depend on the density and distribution of dislocations in the metal before irradiation.

In an initial attempt to observe this expected dependence of irradiation embrittlement on dislocation density and distribution, experiments have been performed on molybdenum with two different types of dislocation structures. The first type of material was heavily cold-worked by swaging and the second type heavily cold-worked and then stress-relieved at 1,000° C. for ½ hr. to give a fine substructure. The starting material in each case was Murex sintered molybdenum containing nominally 50–100 p.p.m. carbon, 50 p.p.m. iron, 20 p.p.m. oxygen, 10 p.p.m. hydrogen, and 5 p.p.m. nitrogen. Both materials were machined into Hounsfield type tensile specimens and four batches of ten specimens of each were irradiated in *Bepo* for 3, 6, 9 and 12 months respectively at a temperature of 40–50° C. The corresponding integrated epithermal neutron fluxes were about 1, 2, 3 and 4×10^{19} n.v.t. The ductile-brittle transition temperatures of the unirradiated materials and of each of these eight batches of irradiated specimens were measured using a modified Hounsfield tensometer operating at a strain rate of $0{\cdot}88 \times 10^{-4}$ sec.$^{-1}$.

The ductile-brittle transition temperature of each batch was taken to be the highest temperature at which no appreciable plastic deformation occurred before fracture. On this criterion the transition temperature for both types of materials was $+120 \pm 10$° C. both before and after irradiation. Moreover, irradiation did not influence the shape of the load-elongation curve at any temperature. The transition temperature of recrystallized specimens of the same batch of molybdenum was -60 ± 10° C.

These results indicate that at least some measure of control of the irradiation embrittlement of body-centred cubic transition metals can be achieved by using materials with controlled dislocation structures. A fuller account and discussion of these results is to be published elsewhere.

This work was initiated under a U.S. Navy Department Contract and in its later stages was financed by the U.K. Atomic Energy Authority and Central Electricity Generating Board. It was carried out under the general direction of Prof. J. G. Ball.

D. N. Sethna
A. A. Johnson
K. J. Proud
S. S. Sheinin

Metallurgy Department,
Imperial College of Science and Technology,
London, S.W.7.

[1] Hull, D., and Mogford, I. L., *Phil. Mag.*, **3**, 1213 (1958).
[2] Cottrell, A. H., *Trans. Amer. Inst. Mech. Eng.*, **212**, 192 (1958).
[3] Johnson, A. A., *Phil. Mag.*, **5**, 413 (1960).

CHEMICAL ENGINEERING

Evidence of Phase Changes in Zirconia from Thermal Etching

ZIRCONIA is known to exist in at least two crystallographic forms. The stable form at room temperatures is monoclinic[1], but this transforms to a tetragonal lattice at some temperature between 950° and 1,250° C. (ref. 2), depending on the purity of the oxide. Cohn[3] has claimed a third form, hexagonal, obtained by heating for prolonged periods above 1,900° C. in a solar furnace. Up to the present, this has not been confirmed, but we believe we may have obtained evidence of three forms of zirconia.

We have recently completed the design, construction and testing of a carbon arc image furnace (unpublished work), which was used to investigate the melting of zirconia. Specimens were prepared from two batches of powder: one (prepared from Travancore beach deposits), with a range of particle size of 30–500μ, was claimed to be of very high purity except for 5·06 wt. per cent of hafnium oxide; the other (presented by Magnesium Elektron, Ltd.), with a range of particle-size of approximately 2–10μ, was analysed by the suppliers as containing, in terms of p.p.m. of zirconium content: 30 hafnium, < 20 manganese, 40 chromium, 460 iron, 153 silicon, < 30 vanadium, 42 nickel and 115 aluminium. The powders were compressed, without any lubricants or binders, into thin disks under a pressure of approximately 40 tons/sq. in., and melted in air in the arc image furnace. Melting took approximately 2 min., after which the specimens were allowed to cool. When the melted surfaces were examined under the microscope, grooves were seen at grain boundaries and some areas also showed surface striations the direction of which changed from one grain to another. These phenomena constitute thermal etching.

The conditions for and possible mechanisms of the formation of boundary grooves and surface striations have been discussed by Chalmers *et al.*[4]. It is concluded that a reduction in free energy of a strain-free lattice takes place by the reduction of surface and grain-boundary free energies. For ionic crystals, it has been shown by Lennard-Jones and Taylor[5] that the surface free energy depends upon the crystallographic orientation of the surface. Experimental evidence of this was obtained when single-crystal spheres of rock salt[6] and of alumina[7] were heated: crystal faces were developed and the spheres changed eventually to polyhedra.

Thermal etching, particularly of the grain-boundary grooves as opposed to the surface striations, has been used to determine the austenitic grain size of iron and steels[8]. This is possible because the grooves formed around the grains of the high-temperature phase persist after a phase change to the low-temperature form has occurred, so that two sets of grain boundary grooves are finally observed. The boundary grooves move as grain-growth occurs, without, in general, leaving traces of their former positions.

Although a number of investigations of the thermal etching of metals have been reported, little attention appears to have been given to the thermal etching of ionic crystals in general[9]. The results obtained with zirconia suggest that the method may be of general use as a rapid means of determining whether phase changes have occurred at high temperatures when the high-temperature phase cannot be retained by fast cooling. The accompanying photographs show part of the melted surface of zirconium with high hafnium oxide content (Fig. 1) and with low hafnium content (Fig. 2). Examination of Fig. 1 shows faint broad grooves delineating a small pentagonal region near the centre. A second set of narrower grooves meet in the centre of this region and in turn cross a third set of broad grooves which appear to be distinct from the first set. Some surface striations are also visible. In Fig. 2 grooves outline a large, roughly equi-axial, region in the centre. Within this region two sets of apparently distinct grooves meet, and a third groove, apparently distinct from both sets, crosses them. It is suggested that these three sets of grooves indicate that zirconia passes through three crystallographic forms in cooling from its melting point to room temperature. However, the possibility cannot be dismissed that some of the grain boundary grooves may be growth scars rather than 'phase scars'. But, the total heating and cooling time was relatively short—probably less than 5 min. for the cycle 1,000° C. to melting point (~ 2,700° C.) to 1,000° C., whereas in the only instance where Chalmers *et al.* reported finding a growth scar (on a thermally etched silver specimen) the time at high temperature was 15 hr. By virtue of Cohn's claim and what appears to be a feasible interpretation of the evidence presented here, the behaviour of zirconia at high temperatures would seem worthy of further attention. It is, perhaps, significant that both Cohn and ourselves have used an image furnace in their preparation of the material. This method of heating[10] avoids contamination from furnace materials which may otherwise occur at high temperatures. Work on this topic is proceeding.

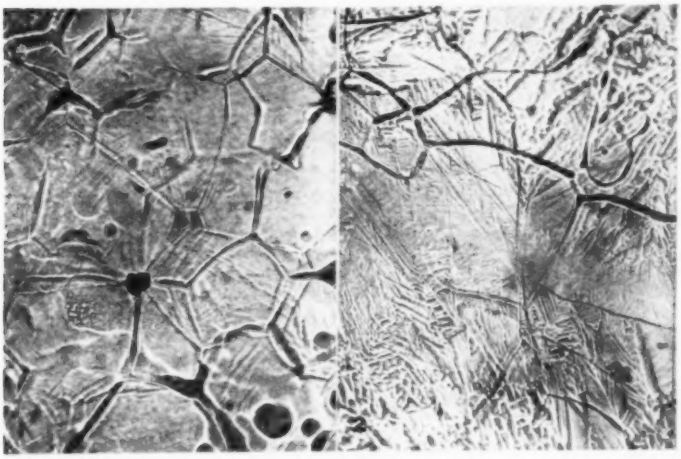


Fig. 1. High-hafnia zirconia. Fig. 2. Low-hafnia zirconia. (× 300)

We thank Prof. Frank Morton for the facilities he has made

available, our colleagues H. Holness[11] and R. W. Adams for the sample of Travancore zirconia and the determination of its hafnium oxide content, and Dr. S. J. Fletcher, of Magnesium Elektron, Ltd., for the sample of low-hafnia zirconia. One of us (G. W.) is indebted to the Department of Scientific and Industrial Research for a maintenance grant.

P. E. Evans
G. Wildsmith

Department of Chemical Engineering,
Fuel Technology and Metallurgy,
Manchester College of Science
and Technology.

[1] Duwez, Pol, and Odell, Frances, *J. Amer. Ceram. Soc.*, **33** (9), 274 (1950).
[2] Mumpton, F. A., and Roy, Rustum, *J. Amer. Ceram. Soc.*, **43** (5), 234 (1960).
[3] *Trans. Electrochem. Soc.*, **68**, 65 (1935). *Ceram. Abstracts*, **18** (9), 244 (1939).
[4] Chalmers, B., King, R., and Shuttleworth, R., *Proc. Roy. Soc.*, A, **193**, 465 (1948).
[5] Lennard-Jones, J. E., and Taylor, P. A., *Proc. Roy. Soc.*, A, **109**, 476 (1925).
[6] Lukirsky, P. I., *C.R. (Doklady) Acad. Sci. U.S.S.R.*, **46**, 274 (1945).
[7] Kuczinsky, G. C., Abernathy, L., and Allen, J., *Kinetics of High Temperature Processes*, 163 (Chapman and Hall, London, 1959).
[8] Miller, O. O., and Day, M. J., *Trans. Amer. Soc. Metals*, **30**, 541 (1942).
[9] Evans, P. E., *Acta Metallurgica*, **5** (6), 342 (1957).
[10] Evans, P. E., *J. Amer. Ceram. Soc.* (in the press).
[11] Holness, H., and Kerr, R. W., *Analyst*, **74** (582), 505 (1949).

CHEMISTRY

Gas Chromatographic Separation of Low-boiling Hydrocarbons using Active Alumina as Support for the Liquid Phase

Systematic research into the behaviour of aluminium oxide as a support in gas chromatographic columns has, to our knowledge, been carried out by Hrapia[1] and Scott[2]. Hrapia was concerned principally with retention volumes and column performance and Scott with the deactivation of alumina with water.

We have found, at column temperatures between 0° and 70° C., that non-volatile liquids such as squalane, triethylene glycol and ββ′-oxydipropionitrile are suitable impregnating agents for alumina supports. The liquid phase is added to the support (γ-$Al(OH)_3$ containing 0·22 per cent by weight Na_2O, grain size 0·1–0·15 mm., calcined for 9 hr. at 400° C.) in dilution with a suitable volatile solvent (for squalane, petroleum ether, 40–70° C.; for polar liquids, methylene chloride) which is evaporated off prior to drying. During this final drying operation (5 hr. at 70° C.) alumina samples treated with polar liquids undergo losses of weight proportional to the quantity of liquid phase added; we can only explain these losses by assuming a release of chemically bound water from the surface of the alumina, suggesting the formation of surface compounds with the support. Aluminas impregnated with squalane show slight hygroscopicity even under drying conditions (compare Fig. 1).

Table 1

Liquid phase in alumina + liquid phase (per cent by weight)	HETP (mm.)		
	Squalane	ββ′-Oxydipropionitrile	Triethylene glycol
5	0·55	0·56	0·63
10	0·69	0·55	0·51
15	1·9	0·62	0·64
20–25	Column performance too low for the separation of low-boiling hydrocarbons		

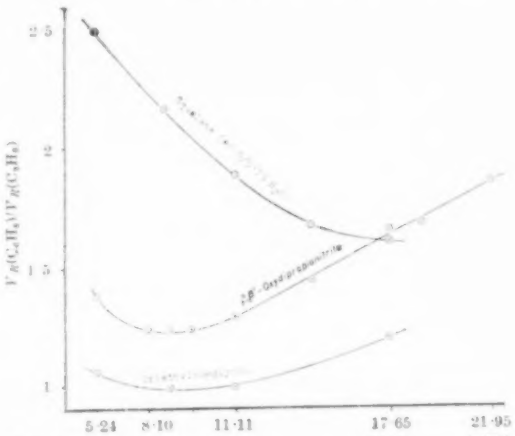


Fig. 1. Polarity charge with addition of liquid phase. V_g measured from air peak

It has been our experience that performances obtained with column packings having alumina as support are superior to those obtained with columns having an inactive support. The HETP values (height of equivalent theoretical plates) in Table 1 were obtained for packings of alumina + liquid phase

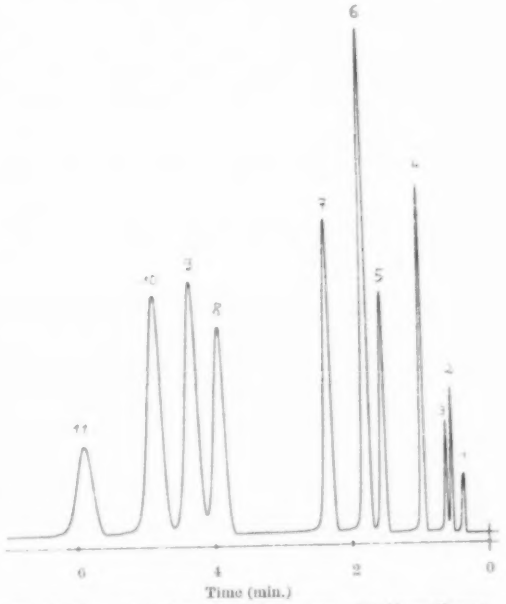


Fig. 2. Separation of C_1—C_4 hydrocarbons. (1) Air–methane; (2) ethane; (3) ethene; (4) propane; (5) propene; (6) *iso*-butane; (7) *n*-butane; (8) butene-1; (9) *iso*-butene; (10) *trans*-butene-2; (11) *cis*-butene-2
Sample size: 0·05 ml. (syringe). Column packing: 18 per cent by weight (= 20·95 gm. per 100 gm. Al_2O_3) of ββ′-oxydipropionitrile on 100–150 mesh Al_2O_3, calcined for 9 hr. at 400° C. Column dimensions: Copper tube, length 2 metres, inner diameter 4 mm. Column temperature: 0° C. Carrier gas: Hydrogen, inlet–outlet pressure ratio 2·66, inlet pressure 24·3 lb./sq. in. gauge, outlet flow-rate 70 ml./min. Thermal conductivity cell: heating current, 400 m.amp.; cell temperature, 0° C.

using *n*-butane as sample and hydrogen as carrier gas (outlet flow-rate 50–70 ml./min.).

Observations of the changes in retention volumes with change in the amount of liquid phase added show that retention volumes decrease continuously with increasing amounts of liquid phase (compared with Hrapia[1]).

Observations of the changes in polarity with change in the amount of liquid phase added are given in Fig. 1 in terms of the ratios of the retention volumes for propene and propane. With squalane the polarity of the alumina – liquid phase system decreases steadily with increasing amounts of liquid, whereas for polar liquids the polarity passes through a minimum. This latter observation indicates that to a certain extent the polarities of carrier and impregnating material compensate each other. The increase in polarity observed when adding polar liquids in amounts beyond those required for compensation is to be attributed mainly to the polarity of the surplus liquid. Mixed phases consisting of triethylene glycol and ββ′-oxydipropionitrile show polarities corresponding to the weight proportions of the individual compounds in the finished mixture.

The optimum conditions for gas chromatographic analysis, namely, short duration, column of low HETP, and polarity adequate for complete separation of sample components, are attained when all these considerations are taken into account. If the separation of air from methane is not required, the results tabulated with Fig. 2 are recommended for the analysis of C_1 to C_4 hydrocarbons (possibly including C_5). Under the same conditions, mixtures containing hydrocarbons up to C_7 have been separated with success. The reproducibility of the measurements is satisfactory. Further results and details will be published elsewhere.

Thanks are due to Dr. P. Vogt, c/o Gebrüder Giulini, GmbH, Ludwigshafen/Rhein (Germany), for providing the alumina supplies.

I. Halász
E. E. Wegner

Institut für Physikalische Chemie
der Universität,
Frankfurt/Main,
Robert-Mayer-Str. 11, Germany.

[1] Hrapia, H., *Gas-Chromatographie* 1958, 93 (Akademie-Verlag, Berlin, 1959).
[2] Scott, C. G., *J. Inst. Pet.*, **45**, 118 (1959).

Gas Chromatographic Analysis of Permanent Gases using Standard Ionization Detector Equipment

Although the most common high-sensitivity detectors now in use for gas chromatography consist of either the flame[1] or the argon ionization device[2], such instruments cannot be used for the analysis of permanent gases when operated in the prescribed fashion. Thus in the argon chamber, the relatively low excitation potential of 11·6 eV. for metastable argon atoms is insufficient to ionize permanent gases which, unlike most organic compounds, have ionization potentials above this level. When we wished to employ gas chromatography for the analysis of gases extracted from the blood of man, it was decided to adapt existing equipment with as little alteration as possible. This was done by substituting ordinary commercial helium for argon as the carrier gas. The ionization chamber was a standard 1 cm. × 1 cm. microdetector which contained a 100-mc. tritium source.

Table 1. Detection of Permanent Gases using a Standard Ionization Detector and Helium as a Carrier Gas

Gas	Minimum sensitivity			Maximum linear range mole/sec.
	μl./sec.	gm./sec.	mole/sec.	
Oxygen	0·015	2×10^{-8}	6×10^{-10}	$1·6 \times 10^{-8}$
Nitrogen	0·035	4×10^{-8}	$1·4 \times 10^{-9}$	$4·2 \times 10^{-8}$
Hydrogen	0·040	$3·6 \times 10^{-8}$	$1·8 \times 10^{-9}$	$1·8 \times 10^{-7}$
Nitric oxide	0·025	5×10^{-8}	1×10^{-9}	$2·5 \times 10^{-8}$
Carbon monoxide	0·10	1×10^{-7}	4×10^{-9}	$6·4 \times 10^{-8}$
Carbon dioxide	0·40	8×10^{-7}	2×10^{-8}	$1·2 \times 10^{-7}$
Methane	0·10	7×10^{-8}	4×10^{-9}	$7·2 \times 10^{-8}$
Ethylene	0·035	4×10^{-8}	$1·5 \times 10^{-9}$	$4·2 \times 10^{-8}$

Optimum operating conditions were obtained by selecting an applied potential which produced a standing current of 1×10^{-9} amp. at room temperature; usually 500 V. was sufficient. Contamination of the helium carrier stream by samples of permanent gases resulted in a decrease in standing current. The extent of this effect was taken as a measure of the quantity of gas being analysed. Although higher base currents gave an increase in sensitivity with a particular cell geometry, there was concomitant increase in the noise-level. Table 1 shows the minimum amount of the various gases which were detected under the conditions of the experiment. The detector was operated at 500 V. and the standing current was $0·88 \times 10^{-8}$ amp. at 27° C. The noise-level was 5×10^{-11} amp.

The range of linearity for each gas is also listed in Table 1. By plotting a typical calibration curve as depicted for oxygen in Fig. 1, quantitative results can be extended beyond the linear range by at least a factor of five. Due to the mechanics of the detection system, the plot of decrease of current versus quantity of permanent gas passing through the detector tends to give a plateau at a minimum current-level. Although this range may differ somewhat for different gases and detectors of different design, the initial slope describing linear range is similar in all instances.

It should be noted that the ionization phenomena in operation in this application are different from those which would be expected if helium of extreme purity was used as the carrier gas[3]. Since increments in current were not noted, it was presumed that a reaction that would involve the contaminant gases and metastable helium atoms did not occur. At an applied potential of 500 V. to the detector, it is probable that the decreases in current which were

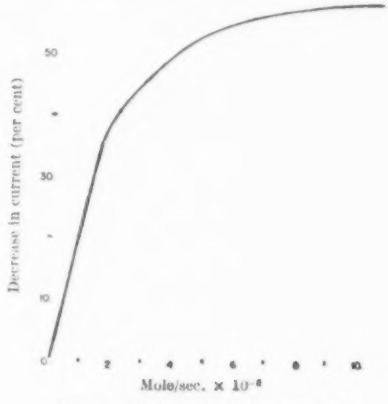


Fig. 1. Calibration curve for oxygen

observed were due to quenching of secondary electrons by molecules of the gas sample. The mode of operation of the detector also differs from that described by Willis[4], where the number of metastable argon atoms in the field were decreased by contaminating the argon carrier gas with ethylene. An electron mobility technique[5] in which a simple pulse generator is employed should offer considerable promise where additional sensitivity is required for the analysis of permanent gases. However, the sensitivity of the present method provides a very convenient compromise between this and conventional techniques where thermal conductivity detectors are used.

This investigation was supported by grants from the National Heart Institute of the National Institutes of Health, the National Dairy Council and the Nutrition Foundation.

R. A. Landowne
S. R. Lipsky

Department of Internal Medicine,
Yale University School of Medicine,
New Haven,
Connecticut.

[1] McWilliam, I. G., and Dewar, R. A., in *Gas Chromatography*, edit. by Desty, D. H. (Academic Press, New York, 1958).
[2] Lovelock, J. E., *J. Chromat.*, **1**, 35 (1958); *Nature*, **182**, 1663 (1958).
[3] Lipsky, S. R., Landowne, R. A., and Lovelock, J. E., *Anal. Chem.*, **31**, 852 (1959).
[4] Willis, V., *Nature*, **184**, 894 (1959).
[5] Lovelock, J. E., *Nature*, **187**, 49 (1960).

α-Configuration of Fibrous Proteins

It is now generally accepted that the polypeptide chain configuration in the group of fibrous proteins designated *k-m-e-f* by Astbury[1], which give the characteristic α X-ray diagram, is closely related to the α-helix described by Pauling, Corey and Branson[2]. In its simplest form, however, the α-helix does not account for the simultaneous appearance of the 5·2 and 1·5 Å. meridional arcs which are the diagnostic feature of the *k-m-e-f* group. Pauling and Corey[3] and Crick[4] suggested independently that these arcs might result from a systematic distortion of the α-helix in which the helix axis itself followed a helical path of large pitch. Detailed calculations by Crick[5] and Lang[6] showed that a group of three such helices twisted about a common axis to form a rope gives a satisfactory agreement with the observed diffraction pattern in the 1·5 and 5·0 Å. regions of the meridian.

We have recently investigated the diffraction pattern of the 3-strand rope in somewhat more detail using an optical diffractometer. While confirming the deductions of Crick and Lang, we find that the remainder of the meridional diffraction does not agree particularly well with the very wide-angle diffraction pattern that we have obtained from certain members of the *k-m-e-f* group. In Fig. 1 the optical transform of the 3-strand rope (*a*) is compared with the patterns obtained from α-keratin (*b*) and dried muscle (*c*). We have therefore explored the alternative possibility that in these proteins the α-helices, instead of being uniformly distorted, are composed of short straight segments with any distortion required for efficient packing being concentrated at a particular residue or residues and resulting in small but abrupt changes in the direction of the helix axis at these points. From the arguments put forward by Crick concerning the packing of helical polypeptide chains, groups of 2, 3 or more chains having the form envisaged above might be expected to form segmented ropes of similar average pitch to the uniformly distorted 3-strand rope.

The diffraction pattern of a segmented rope cannot be investigated without specifying the sequence of segment lengths and inclinations, but the general character of the transform is shown in Fig. 1*d*, which was obtained by an intensity addition of the diffraction from a number of segments 27 Å. in length inclined at a range of angles between 0 and 20° to the fibre axis. The maximum segment length is determined by the gradual divergence of the inclined helix axes and the accompanying departure from the idealized 'knob/hole' packing arrangement envisaged by Crick. A study of atomic models indicates that this length is probably in the region of 20–30 Å. The intensification of the eighth order meridional reflexion (Bragg spacing 24·6 Å.) that we have observed in the X-ray diagram of α-keratins after treatment with many heavy atom stains, for example,

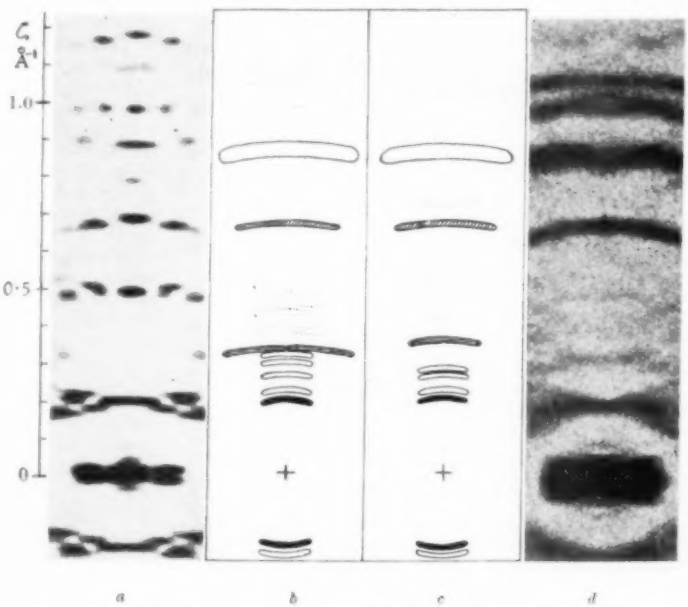


Fig. 1. *a*, The optical transform of the repeating unit of the three-strand rope described by Crick (ref. 5). The major helix is left-handed, the minor helix is right-handed and a β-carbon atom is included in the *L*-configuration about the α-carbon atom. *b*, The spacings and approximate relative intensities in the observed X-ray diffraction pattern from porcupine quill tip. Very weak reflexions are enclosed by a dotted line, weak reflexions by a full line, medium reflexions are shaded and strong reflexions shown solid. *c*, The observed X-ray diffraction pattern from dried toad sartorius muscle. *d*, The simulated optical transform from a segmented cable. The co-ordinate of the '5·2 Å.' arc is 0·19 Å.$^{-1}$ and that of the '1·5 Å.' arc is 0·67 Å.$^{-1}$

silver, mercury, copper and lead, may be associated with this length.

R. D. B. Fraser
T. P. MacRae

Division of Protein Chemistry,
Commonwealth Scientific and Industrial Research
Organization Wool Research Laboratories,
343 Royal Parade,
Parkville, N.2,
Victoria, Australia.

[1] Astbury, W. T., *Proc. Roy. Soc.*, B, **141**, 1 (1953).
[2] Pauling, L., Corey, R. B., and Branson, H. R., *Proc. U.S. Nat. Acad. Sci.*, **37**, 205 (1951).
[3] Pauling, L., and Corey, R. B., *Nature*, **171**, 59 (1953).
[4] Crick, F. H. C., *Nature*, **170**, 882 (1952).
[5] Crick, F. H. C., *Acta Cryst.*, **6**, 685, 689 (1953).
[6] Lang, A. R., *Acta Cryst.*, **9**, 436 (1956).

BIOCHEMISTRY

Nature of Thyroxine-binding Globulin in Human Serum

The term thyroxine-binding globulin is often used to denote a serum protein fraction with a mobility intermediate between those of α_1- and α_2-globulins in paper or moving-boundary electrophoresis in veronal buffer, *p*H 8·6, ionic strength 0·05–0·10 (ref. 1). However, with the introduction of supporting media such as agar and starch gels and the use of different buffers, ionic strength or *p*H for paper electrophoresis, binding of thyroid hormones has also been detected in the 'prealbumin' zone[2]. Although the proteins of the 'prealbumin' zone obtained under different conditions are not likely to be identical, a strong thyroxine-binding property was detected in human serum prealbumin rich in tryptophan[3], as obtained from Prof. Schultze[4]. From chemical and immunological observations I concluded that the tryptophan-rich prealbumin, present as a complex in the α-globulin fraction, might be responsible for much of thyroxine-binding in human serum[5]. Since then, an α-globulin-type of thyroxine-binding protein has been obtained in this laboratory (unpublished results); the nature of this protein does not support the hypothesis that the tryptophan-rich prealbumin is involved in binding thyroxine. One possible explanation for this discrepancy is that Schultze's prealbumin preparation contained traces (1–2 per cent) of thyroxine-binding globulin which were responsible for the production of antibodies to it present in antisera against this prealbumin. In fact, multiple precipitation lines were observed in immunological studies using rabbit anti-human prealbumin serum[5]. The experiments to be described support this explanation and throw further light on the nature of the thyroxine-binding globulin in human serum.

A protein with strong thyroxine-binding properties was isolated (or prepared as an enriched fraction) from whole human serum, human cerebrospinal fluid and Cohn fractions IV-4 and IV-9 by a method which will be described elsewhere. The same major component was obtained from all the starting materials and will be referred to as thyroxine-binding globulin. A 1 per cent solution of this thyroxine-binding protein in 0·15 *M* sodium chloride was generally used for immunological studies. In Fig. 1 is shown a typical result observed when preparations of thyroxine-binding globulin were compared with tryptophan-rich prealbumin using rabbit anti-prealbumin serum (also

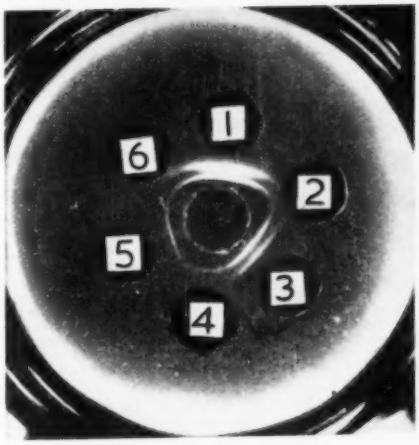


Fig. 1. Immunological interaction, using Ouchterlony's double-diffusion technique in agar gel, between rabbit antiserum against human serum tryptophan-rich prealbumin (ref. 4) (central well) and (1) tryptophan-rich prealbumin, (2) thyroxine-binding globulin prepared from unfractionated human serum, (3) Cohn fraction IV-9, (4) and (5) two different preparations of thyroxine-binding globulin made from Cohn fraction IV-9, and (6) thyroxine-binding globulin prepared from human cerebrospinal fluid

obtained from Prof. Schultze) using Ouchterlony's double-diffusion technique[6]. Two major precipitation lines were seen for the tryptophan-rich prealbumin and Cohn fraction IV-9. A third line was also observed, if human serum was tested (not shown in Fig. 1). Only one line could, however, be detected in preparations of thyroxine-binding globulin, irrespective of the source. This precipitation line was continuous for the different preparations and with one of the lines obtained with tryptophan-rich prealbumin, Cohn fraction IV-9, and with whole serum, Cohn fraction IV-4 and cerebrospinal fluid, which were tested separately. This indicated that the thyroxine-binding globulin is an antigen common to all the preparations tested.

Immuno-diffusion studies by the method of Allison and Humphrey[7] helped in deciding whether the tryptophan-rich prealbumin itself was not the common antigenic component. In this method the antigen and antibody troughs are placed at right angles, as shown in Fig. 2, and the angle θ formed between the precipitation line and the antigen trough is measured. The diffusion coefficients and consequently the relative molecular weights of the antigens were estimated from the equation, $\tan\theta = (D_g/D_b)^{1/2}$, where D_g and D_b are diffusion coefficients of the antigen and antibody respectively. Two major precipitation lines were again observed with the prealbumin (Fig. 2*a*), and the molecular weights of the two antigens were estimated to be about 60–65,000 for component 1 and 40–45,000 for component 2. Component 1 therefore corresponds to tryptophan-rich prealbumin itself, which has a molecular weight of 61,000 (ref. 4). With a preparation of thyroxine-binding globulin (Fig. 2*b*), only one line was observed, corresponding to an antigen of molecular weight of 40–45,000. This is the common antigen present in all the samples shown in Fig. 1; its lower molecular weight is compatible with the precipitation occurring nearest to the antibody trough in Fig. 1. It is therefore concluded that Schultze's tryptophan-rich prealbumin is not alone involved (either free or

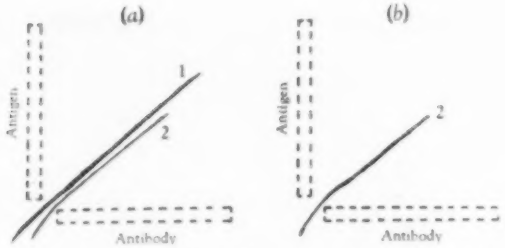


Fig. 2. Immunological reaction obtained using the technique of placing antigen and antibody troughs at right-angles, thus permitting an estimation of diffusion coefficients of antigens (ref. 7). The antibody trough contained rabbit antiserum against human serum tryptophan-rich prealbumin. (*a*) The antigen trough contained a 1·5 per cent solution of tryptophan-rich prealbumin. (*b*) The antigen was thyroxine-binding globulin obtained from Cohn fraction IV-9

complexed) in the transport of thyroid hormones in human blood, contrary to a previous suggestion[5], but that a distinct thyroxine-binding protein of a smaller size is responsible. The above immunological work also shows that the samples of tryptophan-rich prealbumin studied in this laboratory contained traces of thyroxine-binding globulin, estimated to be about 1–3 per cent of the protein from its unusually low binding capacity in the prealbumin samples.

Physical and chemical measurements made on preparations of thyroxine-binding protein have all confirmed the above conclusions. Zone electrophoresis on paper, cellulose acetate, agar gel and starch gel in various buffers, immunoelectrophoresis, sedimentation in the ultracentrifuge and measurement of tryptophan and sugar content reveal the differences between thyroxine-binding globulin and tryptophan-rich prealbumin. On the other hand, thyroxine-binding globulin resembles the α_1-glycoproteins of small molecular weight of Schultze and Schmid and their collaborators[8], although it may not be the same as the protein described by these workers. Some of the similarities and differences between thyroxine-binding globulin and other serum proteins, which will be described elsewhere, are summarized in Table 1.

Table 1. Comparison of Some Properties of Thyroxine-binding Globulin with those of Some Isolated Human Serum Proteins

Sample	Electrophoretic mobility (-10^{-5} cm.^{2} V.$^{-1}$ sec.$^{-1}$)	Sedimentation constant ($S_{20,w}$)	Chemical analysis
TBG (unfractionated serum)	4·7 (*p*H 8·6) 1·7 (*p*H 4·5)	3·3	
TBG (isolated)	4·9 (*p*H 8·6) 1·8 (*p*H 4·5)	3·5	High sugar, low lipid, low tryptophan
α_1-Glycoprotein (ref. 8)	5·0 (*p*H 8·6)	2·9, 3·1, 3·5	High sugar
Prealbumin (ref. 4)	9·0 (*p*H 8·6)	4·2	High tryptophan

It is important to note that the sedimentation constant and electrophoretic mobilities of isolated thyroxine-binding globulin compare well with the values derived by Robbins, Petermann and Rall[9] for the major component in unfractionated human serum to which thyroid hormones are bound. The evidence presented here does not attempt to explain the diversity of thyroxine-binding protein zones when various conditions of electrophoresis of human serum are used[9]. It is concluded from these observations that the principal thyroxine-binding protein in human serum is an α_1-glycoprotein of small molecular weight; this necessitates a revision of the earlier suggestion that the tryptophan-rich prealbumin was alone involved in the transport of thyroid hormones in human blood[5].

I thank Dr. R. B. Pennell for Cohn fractions of human plasma; Prof. H. E. Schultze for human serum prealbumin rich in tryptophan, and immune rabbit serum; Dr. Marshall for human cerebrospinal fluid; Dr. K. Schmid for α_1-acid glycoprotein; Dr. P. Charlwood for ultra-centrifugal analysis and, finally, Drs. W. Gratzer and D. Tee for invaluable help and advice in zone electrophoresis, immunoelectrophoresis and tryptophan determinations.

J. R. Tata*

National Institute for Medical Research,
Mill Hill,
London, N.W.7.

* Beit Memorial Fellow.

[1] Robbins, J., and Rall, J. E., *Rec. Progr. Hormone Res.*, **13**, 161 (1957). Pitt-Rivers, R., and Tata, J. R., *The Thyroid Hormones* (Pergamon Press, London, 1959). Tata, J. R., *Brit. Med. Bull.*, **16**, 142 (1960).

[2] Rich, C., and Bearn, A. G., *Endocrinol.*, **62**, 687 (1958). Ingbar, S. H., *ibid.*, **63**, 256 (1958). Tata, J. R., *Brit. Med. Bull.*, **16**, 142 (1960). Myant, N. B., and Osorio, C., *J. Physiol.* (in the press).

[3] Tata, J. R., *Biochem. J.*, **72**, 222 (1959).

[4] Schultze, H. E., Schönenberger, M., and Schwick, G., *Biochem. Z.*, **328**, 267 (1956).

[5] Tata, J. R., *Nature*, **183**, 877 (1959).

[6] Ouchterlony, O., *Acta Path. Microbiol. Scand.*, **25**, 186 (1948).

[7] Allison, A. C., and Humphrey, J. H., *Immunol.*, **3**, 95 (1960).

[8] Schultze, H. E., Göllner, L., Heide, K., Schönenberger, M., and Schwick, G., *Z. Naturf.*, **10**, b, 463 (1955). Schmid, K., Benczc, W. L., Nussbaumer, T., and Wehrmüller, J. O., *J. Biol. Chem.*, **234**, 529 (1959).

[9] Robbins, J., Petermann, M. L., and Rall, J. E., *J. Biol. Chem.*, **212**, 403 (1955). Petermann, M. L., Robbins, J., and Hamilton, M. G., *J. Biol. Chem.*, **208**, 369 (1954).

Influence of the Charge on a Serum Protein Molecule and its Ability to stimulate or inhibit the Phagocytosis of Bacteria by Leucocytes

The present work was undertaken to investigate the effect of various human serum proteins upon the phagocytosis of *Staphylococci* by human leucocytes, and in particular to show the effect of modifying the net charge on the serum protein molecule upon the ability of the protein to stimulate or inhibit phagocytosis.

A modification of the slide-cell technique of Wright[1] has been used to assess the phagocytic ability of human leucocytes towards bacteria.

Human defibrinated blood from healthy Group O donors has been used. Part of any given sample of blood was used in its defibrinated condition without further treatment, but a part was centrifuged at high speed, and samples of serum and packed erythrocytes pipetted off under aseptic conditions and then re-mixed to give leucocyte-free blood of the same hæmatocrit as the original. The total leucocyte count of this latter sample was less than 3 per cent of the original count.

The slide-cells were constructed from two microscope slides separated by five strips of waxed paper, prepared under sterile conditions, in such a way that four shallow compartments were produced as shown in Fig. 1.

0·1 ml. of a 1 in 200,000 normal saline dilution of a peptone–water culture of *Staphylococcus aureus* (Wellcome Collection, No. *CN* 3638) was mixed with

0·1 ml. of an isotonic solution in saline of the protein to be tested, plus 0·8 ml. of the blood or leucocyte-free blood. The compartments of the slide-cell were filled as indicated and sealed around with melted paraffin wax, incubated at 37° C. for 15–20 hr., and then the number of bacterial colonies seen in ten low-power microscope fields noted for each compartment.

Human serum from healthy Group O donors was used for the preparation of the serum protein fractions. The serum was brought to 55 per cent saturation at 4° C. with ammonium sulphate (Analar grade), centrifuged at this temperature, and the precipitate re-dissolved in half the original volume of distilled water. Both this solution and the supernatant from the ammonium sulphate fractionation were then exhaustively dialysed against distilled water and afterwards lyophilized for storage.

The two serum protein fractions obtained were then used to prepare samples of both the acetylated and the methyl esterified derivatives, using the methods of Fraenkel-Conrat[2]. The methyl esterification was performed by treating a methanol solution, so far as it was soluble, of the protein at −15° C. with a small quantity of concentrated hydrochloric acid. Having kept the reaction mixture in the deep freeze for 48 hr., it was exhaustively dialysed against distilled water and lyophilized.

Electrophoretic separation of the proteins was done in duplicate on Whatman 3*MM* paper in barbitone buffer *p*H 8·6, ionic strength 0·05. After 18 hr. separation at 7 V./cm., one strip from each pair was dried and stained with bromophenol blue. The electropherograms were scanned in a slightly modified EEL scanner. The unstained strips were then eluted in order to measure ability of the protein fractions to stimulate or inhibit phagocytosis. The areas eluted are represented by the shaded areas in the electropherograms in Fig. 2. The eluant used was the same buffer as was used for the electrophoresis, and the eluted proteins were dialysed free of barbitone through 'Cellophane' tubing against normal saline containing 0·001 *M* phosphate buffer *p*H 7·2. The proteins were then concentrated by ultrafiltration through 'Cellophane' tubing to a final concentration of 5 per cent w/v, filtered free of bacteria, and used in the test of phagocytosis.

From Fig. 1 it is seen that the difference between the number of bacterial colonies which appear in a compartment containing leucocytes and in one which is devoid of leucocytes represents the antibacterial capacity of the leucocytes under the conditions in

	A	B	C	D
	Red cells Serum White cells Normal saline	Red cells Serum Normal saline	Red cells Serum White cells Serum protein in normal saline	Red cells Serum Serum protein in normal saline
Number of bacterial colonies seen after incubation in ten low power microscope fields, in each compartment.	w	x	y	z
Phagocytic index	Control: $\frac{x-w}{x}$ %		Test: $\frac{z-y}{z}$ %	

Fig. 1. Construction of slide-cells and calculation of results

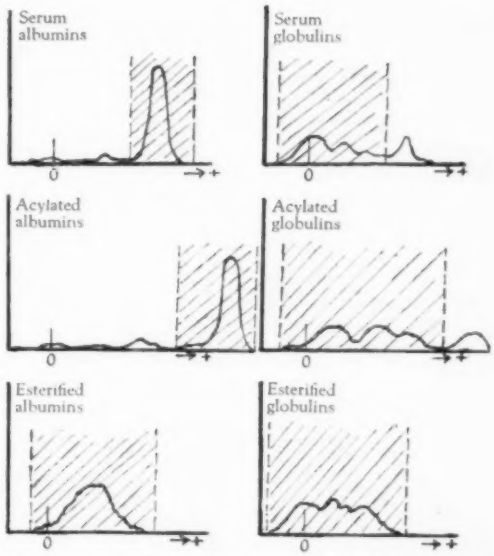


Fig. 2. Electropherograms of proteins, 0 being the point of application

question. For simplicity this will be referred to as the phagocytic ability.

Fig. 2 and Table 1 summarize the results obtained. In confirmation of the work of Tullis[3], the albumin fraction of the serum inhibits phagocytosis, and there is a significant stimulation with the globulins. Acetylation of a serum protein increases the negative charge on the molecule and either increases the inhibitory properties of albumins or decreases the stimulatory property of globulins. On the other hand, the esterification has been shown by electrophoresis to decrease the net negative charge on the serum protein molecule and increase the stimulatory effects of the globulins; but for some unexplained reason has had little effect on the properties of albumins in phagocytosis.

Table 1. Phagocytic Indices in a Final Concentration of the Added Protein of 1 per cent w/v

Substance	Phagocytic index	
	Mean	Standard error
Normal saline control	61	± 3·1
Serum albumins	43	± 2·7
Serum globulins	70	± 3·3
Acylated albumins	29	± 1·9
Acylated globulins	55	± 2·4
Esterified albumins	31	± 2·7
Esterified globulins	84	± 3·6

It would seem from these results that, for a given protein, the more negative its charge the more inhibitory it is towards phagocytosis, and conversely, the less the negative charge the more it will stimulate phagocytosis. In the case of the globulins, there seems to be the potentiality for either stimulation or inhibition of phagocytosis; yet the albumins seem to be capable only of inhibition. Clearly, therefore, there are other properties of a protein molecule besides its charge which determine its effect on phagocytosis.

I wish to thank Prof. G. A. H. Buttle for introducing me to the methods for measuring phago-

cytosis, and Dr. I. A. Hansen for suggesting the present investigation.

B. J. Northover

Department of Pharmacology,
Christian Medical College,
Vellore, South India.

[1] Wright, A. E., and Colebrook, L., "Technique of the Teat and Capillary Glass Tube" (Livingstone, London, 1921).
[2] Fraenkel-Conrat, H., in "Methods in Enzymology", edit. by Kaplan and Colowick, **4** (Academic Press, New York, 1957).
[3] Tullis, J. L., and Surgenor, D. M., *Ann. N.Y. Acad. Sci.*, **66**, 386 (1956).

Synthesis of Biologically Active Cellulose Derivatives of Enymes

Modified celluloses have been combined chemically with a variety of enzymes, with retention of enzymatic activity but with interesting and useful modifications of some properties. Derivatives have been prepared with carboxymethylcellulose and diazobenzylcellulose.

All derivatives are covalently linked and are stable to water, salt solution, acid, and buffer, and all can be dried by lyophilization without loss in activity. Derivatives of diazobenzylcellulose are insoluble, whereas those of carboxymethylcellulose vary from insoluble to water soluble, depending upon the characteristics of the carboxymethylcellulose. Soluble derivatives possess activity comparable with or greater than that of the free enzyme, but the insoluble derivatives are considerably less active.

Coupling with carboxymethylcellulose was effected by a modification of the azide method of Michael and Evers[1]. The entire process was carried out at 0° in a centrifuge bottle. Carboxymethylcellulose azide was prepared by suspending 1 gm. of its hydrazide in 150 ml. of 2 per cent hydrochloric acid solution and slowly stirring in 9 ml. of 3 per cent sodium nitrate solution. After 20 min., insoluble carboxymethylcellulose azide was separated by centrifugation and washed with 150 ml. of dioxane and then with distilled water to neutrality. Soluble carboxymethylcellulose azide, in the supernatant liquid, was precipitated by adding methanol to a final volume of 62 per cent, separated, and then washed several times with phosphoric acid solution at *p*H 2 before a final wash with distilled water. The carboxymethylcellulose azides were then separately stirred with 250–450 mgm. enzyme in 100 ml. of 0·05 *M* phosphate buffer at *p*H 8·7 for 2 hr. The insoluble derivative was then adjusted to *p*H 4 with 0·1 *M* phosphoric acid, separated, washed twice with 150 ml. of *p*H 3 water and once with distilled water, and finally lyophilized. The soluble derivative was precipitated at *p*H 3·5 with methanol (13 per cent) at − 5°, washed once with dilute phosphoric acid at *p*H 2 and once with water, and then lyophilized.

Soluble derivatives were obtained from more highly substituted cellulose, whereas lower degrees of substitution yielded derivatives with varying solubility properties. For example, a cellulose with low substitution (carboxymethylcellulose azide was prepared from carboxymethylcellulose products with different carboxyl equivalents obtained from Hercules Powder Co., Wilmington, Delaware, and Brown Co., Berlin, New Hampshire) yielded only an insoluble derivative, while one with an intermediate degree of substitution yielded an enzyme derivative that was soluble at *p*H 7 but insoluble at *p*H 3. It is not possible to be specific in predicting the solubility of the derivatives because of such factors as the uniformity of substitution, the number of free carboxyl groups in the final product, and the condition of the cellulose fibre.

Table 1. Comparison of Protein coupled and Enzyme Activity demonstrated by Chymotrypsin Derivatives (Typical Results)

Substitution on cellulose	Low	High		
Solubility of derivative	Insoluble	Insoluble	Alkali-soluble	Soluble
Mgm. protein coupled*/gm. derivative	95	350	221	553
Mgm. enzyme equivalent†/gm. derivative	30	86	172	1,071

* The protein was determined by spectrophotometric analysis at 280 mμ on the solutions before and after coupling.
† The quantity of enzyme in the derivative was calculated by comparison with the activity of the free enzyme on acetyl tyrosine ethyl ester (ref. 2).

Because of variations in the amount of carboxyl substitution on the cellulose, the quantity of enzyme coupled varies. The greater the original degree of substitution the greater the enzymatic activity of the derivatives: surprisingly, the activities of the soluble derivatives are equal to or greater than the activity of the free enzyme (Table 1).

In general, the activity of the derivative is related to the degree of hydration of the product rather than to the amount of enzyme coupled. This has been shown by comparing two insoluble derivatives with equal amounts of protein substituted on the cellulose. A derivative which had a tendency to swell in solution was 2–3 times as active as a derivative that did not show this property.

Limited studies indicated that both insoluble and soluble carboxymethylcellulose derivatives of chymotrypsin are more stable to heat than free chymotrypsin, the insoluble derivative possessing the greatest stability. There appears to be no shift in the *p*H optimum. The insoluble derivatives of trypsin and chymotrypsin are more active on small substrates, for example, acetyl tyrosine ethyl ester[2], than on large substrates, for example, haemoglobin[3], showing some spatial limitation. Furthermore, the trypsin inhibitor of blood fails to inhibit the insoluble trypsin derivative, which further suggests spatial interference.

The second type of derivative was not so successful as the first, but proved that the cellulose–enzyme union is not restricted to one type of linkage. Insoluble diazobenzylcellulose derivatives of ribonuclease and chymotrypsin were synthesized by the coupling procedure of Campbell *et al.*[4]: 1 gm. of enzyme in 100 ml. of 0·05 *M* borate buffer at *p*H 8·7 was treated with 1 gm. of diazotized *p*-aminobenzylcellulose at 0°. Analysis indicated that the ribonuclease derivative was as much as 23 mgm. per cent protein, and the chymotrypsin derivative 34 mgm. per cent protein. However, the activities determined spectrophotometrically for ribonuclease[5] and titrimetrically for chymotrypsin[2] correspond to only 0·6 mgm. per cent, and 1·3 mgm. per cent enzyme, respectively. More work on this series may improve the activity incorporated into the derivative.

The use of modified cellulose in the synthesis of enzymatic derivatives should be applicable to an extensive series of purified enzymes. Not only may a study of these derivatives reveal information on how insoluble enzymes function, but it may also reveal a very practical way to use certain enzymes. For example, the insoluble carboxymethylcellulose-trypsin derivative has been used in our laboratory to effect a controlled chymotrypsinogen-to-chymotrypsin conversion. After the conversion, the derivative

was easily recovered, leaving no trypsin contamination of the chymotrypsin; and with proper precautions, the derivative was re-usable. Similar applications could be suggested for other enzymes.

MILTON A. MITZ*
LOUIS J. SUMMARIA

Research Division,
Armour and Company,
Chicago 9, Illinois.

* Present address: Melpar Inc., Falls Church, Va., U.S.A.

[1] Michael, F., and Evers, J., *Makromol. Chem.*, **3**, 200 (1949).
[2] Schwert, G. W., Neurath, H., Kaufmann, S., and Snoke, J. E., *J. Biol. Chem.*, **172**, 221 (1948).
[3] Anson, M. L., *J. Gen. Physiol.*, **22**, 79 (1938).
[4] Campbell, D. H., Luescher, E., and Lerman, L. S., *Proc. U.S. Nat. Acad. Sci.*, **37**, 575 (1951).
[5] McDonald, M., "Methods in Enzymology", **2**, edit. by Colowick, S. P., and Kaplan, N. O., 427 (Academic Press, Inc., New York, 1957).

Distribution of Coenzyme Q in Rat Liver Cell Fractions

COENZYME *Q* (Co*Q*), which is widely distributed in animal, plant and microbial sources, has been implicated in electron transport[1] and generally assumed to be associated with mitochondria. However, it has also been found in non-mitochondrial fractions of green leaves, although it appears to be concentrated in mitochondria[2]. A similar distribution has now been demonstrated in rat liver cell fractions.

Livers of stock colony rats were homogenized and fractionated by Schneider's method[3]. The following determinations were made: coenzyme *Q* by the decrease in absorption at 275 mμ on addition of sodium borohydride[4], succinic dehydrogenase by the reduction of dichlorophenol indophenol[5], $CoQH_2$ oxidation[6] (which is sensitive to antimycin and cyanide and therefore a measure of cytochrome oxidase), acid phosphatase[7] after pre-incubation for 1 hr. at 37° C., esterase activity with menadiol diacetate as substrate (Ramasarma, T., unpublished results), and protein by the biuret method[8].

Determinations of the distribution of coenzyme *Q* in rat liver cell fractions, giving a set of typical results of a number of experiments, are presented in Table 1. The mitochondrial fraction contained only 41 per cent of the total coenzyme *Q* and the rest of it was distributed in other fractions. The presence of coenzyme *Q* in all the fractions was confirmed by reverse phase paper chromatography. The large proportion of coenzyme *Q* present in the nuclear fraction (37·5 per cent) does not appear to be due to contamination of whole cells or mitochondria, since the acid phosphatase, $CoQH_2$ oxidation and esterase activities were low. But, since 30 per cent of the total succinic dehydrogenase was recovered in this fraction, the possibility of contamination by mitochondrial fragments cannot be excluded. The amount of coenzyme *Q* present in the fraction of sub-microscopic particles, the total as well as on the protein basis, was about one-third of that in the mitochondria, but the activities of succinic dehydrogenase and $CoQH_2$ oxidation in this fraction were several times lower in content and specific activity in comparison to mitochondria. Therefore the coenzyme *Q* in this fraction cannot be of mitochondrial origin, but appears to be partly constitutive and thus a wider role for coenzyme *Q* is suggestive. Whether the coenzyme *Q* present in sub-microscopic particles participates in the two oxidative enzyme

Table 1. DISTRIBUTION OF COENZYME *Q* IN RAT LIVER CELL FRACTIONS

	Nuclei	Mitochondria	Sub-microscopic particles	Supernatant
Coenzyme *Q* μmole/gm. protein	0·570	0·940	0·330	0·071
(per cent)	37·5	41	14·5	7
Succinate dehydrogenase activity	0·0095	0·0240	0·0040	0·0030
(per cent)	30	50	6	14
$CoQH_2$ oxidation activity	0·0007	0·0095	0·0008	0·0004
(per cent)	9	78	5	8
Acid phosphatase activity	0·0040	0·0340	0·0150	0·0035
(per cent)	10	56	21	13
Esterase activity	0·005	0·285	0·025	0·240
(per cent)	4	17	46	33
Protein (gm.)	0·425	0·280	0·228	0·630
(per cent)	27	18	14	41

The enzyme activities are expressed as μmoles substrate-change per min. per mgm. protein at 37° C. The total quantity present in all the four fractions is taken as 100 per cent.

systems—reduced diphosphopyridine nucleotide cytochrome *c* reductase and the oxidation of *L*-gulono-γ-lactone—will be of interest, particularly in view of the observation of an involvement of a lipid co-factor in the latter system[9]. It is interesting to note that vitamin K, also a lipid-quinone, was found to be similarly distributed: nuclei 24 per cent, mitochondria 61 per cent, and sub-microscopic particles and supernatant 15 per cent, as tested by its biological activity[10].

We wish to thank Prof. P. S. Sarma and Dr. J. Ganguly for their interest in this work.

P. SESHADRI SASTRY
J. JAYARAMAN
T. RAMASARMA*

Department of Biochemistry,
Indian Institute of Science,
Bangalore 12.

* Council of Scientific and Industrial Research Scientists' Pool Officer.

[1] Green, D. E., and Lester, R. L., *Fed. Proc.*, **18**, 987 (1959).
[2] Crane, F. L., *Plant Physiol.*, **34**, 128 (1959).
[3] Schneider, W. C., *J. Biol. Chem.*, **176**, 259 (1948).
[4] Lester, R. L., and Crane, F. L., *J. Biol. Chem.*, **234**, 2169 (1959).
[5] Green, D. E., Mii, S., and Kohout, D. M., *J. Biol. Chem.*, **217**, 651 (1955).
[6] Ramasarma, T., and Lester, R. L., *J. Biol. Chem.*, **235**, 3309 (1960).
[7] Goodlad, G. A. G., and Mills, G. T., *Biochem. J.*, **66**, 346 (1957).
[8] Gornall, A. G., Bardawill, C. J., and David, M. M., *J. Biol. Chem.*, **177**, 751 (1949).
[9] Chatterjee, I. B., Kar, N. C., Ghosh, N. C., and Guha, B. C., *Arch. Biochem. Biophys.*, **86**, 154 (1960).
[10] Green, J. P., Sondergaard, E., and Dam, H., *Biochim. Biophys. Acta*, **19**, 182 (1959).

Conversion of DL-*m*-Tyrosine to Dopamine in the Rat

THE formation of catecholamines *in vivo* has been demonstrated using phenylalanine[1], tyrosine[2,3], 3,4-dihydroxyphenylalanine (dopa)[2,4], and 3,4-dihydroxyphenylserine[5] as precursors. *m*-Tyrosine (3-hydroxyphenylalanine) has been considered in this laboratory as another possible precursor, for it is decarboxylated by mammalian organs *in vitro*[6] and *in vivo*[7], and its decarboxylation product, *m*-tyramine, is found in normal[8] and phenylketonuric[9] urines, and in urine of subjects who have received an inhibitor of monoamineoxidase[10]. The recent characterization of leptodactyline as the trimethyl-ammonium salt of *m*-tyramine[11] suggests that at least some animal species can form *m*-tyrosine, although this amino-acid has not yet been identified in any natural source.

Table 1. URINARY EXCRETION OF DOPAMINE IN THE RAT

Exp.	Compound administered*	Dose (mgm./kgm.)	Mean body-weight (gm.)	Dopamine excreted per rat (μgm.)	Recovery of *m*-tyrosine as dopamine (per cent)
1†	None		238	0·7	—
	DL-*m*-Tyrosine	100	228	38	0·26
	DL-*m*-Tyrosine	100	212	28	0·19
2	None		150	1·5	—
	DL-*m*-Tyrosine	83	148	51	0·47
	DL-3,4-Dopa	5	147	162	28·20
	DL-3,4-Dopa	15	172	449	22·50
3	DL-*m*-Tyrosine	50	218	22	0·24
4	DL-*m*-Tyrosine	100	101	25	0·27
	Same, but pre-treatment with reserpine (see text)	100	72	17	0·25

* Injected intraperitoneally in aqueous solution; controls received equivalent volume of saline. Three rats were caged together and their pooled urine was analysed for dopamine fluorometrically (ref. 13).
† In exp. 1 urine was collected for 5 hr.; in exps. 2 and 3, 19 hr.; in exp. 4, 21 hr.

We have found by administering DL-*m*-tyrosine (California Corp. for Biochemical Research, Los Angeles) to rats that excess dopamine (3,4-dihydroxyphenylethylamine) is excreted in the urine. In exps. 1–3 of Table 1, 0·19–0·47 per cent of the dose administered was excreted in the urine as the catecholamine. The urinary catechols obtained in exp. 1 were adsorbed on alumina and eluted with 0·5 *M* acetic acid; fluorescence of the eluate was measured at 335 mμ (activation at 280 mμ) in an Aminco–Bowman spectrophotofluorometer. With these conditions, dopamine fluoresces maximally, but specificity is lost by comparison with the oxidative procedure in which a fluorophore is formed from dopamine, but not from the other catecholamines, the catecholic acids[12], or *m*-tyrosine. This fluorescence, calculated as though it were all due to dopamine, gave a recovery of 0·26 per cent based on the DL-amino-acid; this is to be compared with the recovery of 0·19 per cent, estimated on the same material but using a specific fluorometric method[13]. In two other experiments of the same type the values for recovery were 0·27 and 0·28 per cent by the non-specific, and 0·25 and 0·27 per cent by the specific, fluorescence measurements, respectively. The yield from dopa is much greater (exp. 2).

Descending chromatography of the alumina eluates of exp. 1 was carried out on Whatman No. 3*MM* filter paper, using *n*-butanol/acetic acid/water (7 : 1 : 2), for 18 hr. After drying and spraying with ferricyanide reagent the eluate of urine of rats receiving *m*-tyrosine showed one spot; this was at the same position on the chromatogram as authentic dopamine. The eluate of control urine showed no such spot. *m*-Tyrosine is not adsorbed on alumina under the conditions used for preparation of the eluates.

Nine rats weighing 225–250 gm. were injected intraperitoneally with 200 mgm. of *m*-tyrosine per kgm. 30 min. later they were killed by guillotining, and the kidneys were removed for analysis. These organs contained 0·54 μgm. ± 0·09 (*S.E.*) of dopamine per pair of kidneys. A similar group of nine animals which had received 5 mgm./kgm. of tranylcypromine, a potent monoamine oxidase inhibitor, gave a mean of 1·98 μgm. ± 0·31 (*S.E.*). Control values (3 rats each) were 0·07 μgm. (range, 0·06–0·08) and 0·26 μgm. (0·17–0·30), respectively.

The excess urinary dopamine found after administration of *m*-tyrosine to rats as described could possibly be attributed to release of the amine from storage sites in the tissues. In order to verify this point, rats were injected intravenously with 10 mgm. of reserpine per kgm. to deplete the tissues of catecholamines, and 72 hr. later were given 50 mgm. *m*-tyrosine/kgm. intraperitoneally; controls were treated similarly except that the vehicle alone was substituted for the solution of reserpine injected. Matched groups receiving reserpine or vehicle, but not the amino-acid, were used to correct the values of the groups getting *m*-tyrosine; the level of this endogenous urinary dopamine is very low. It will be noted in Table 1, exp. 4, that the reserpine-treated and placebo rats excreted the same proportion of the administered amino-acid as dopamine. This indicates that a releasing action by *m*-tyrosine on 'bound' tissue dopamine does not play any part in the results obtained here.

The conversion of *m*-tyrosine to dopamine involves (1) oxidation of the ring in the *para* position and (2) decarboxylation. The order in which these occur and the mechanism of the ring oxidation are not known. Microsomal enzymes of the liver are known to oxidize aromatic rings in more than one position, but they do not appear to act in this way on L-phenylalanine[14]. Whether the same is true of *m*-tyrosine awaits further experiment.

This investigation has been supported by a Dominion-Provincial Mental Health Research Grant. Tranylcypromine (*SKF* 385-*A*, *trans*) was generously provided by Smith, Kline and French Laboratories, Philadelphia, Pa.

T. L. SOURKES
G. F. MURPHY
A. RABINOVITCH

Allan Memorial Institute of Psychiatry
and McGill University,
Montreal 2.

[1] Gurin, S., and Delluva, A. M., *J. Biol. Chem.*, **170**, 545 (1947).
[2] Udenfriend, S., and Wyngaarden, J. B., *Biochim. Biophys. Acta*, **20**, 48 (1956).
[3] Rosenfeld, G., Leeper, L. C., and Udenfriend, S., *Arch. Biochem. Biophys.*, **74**, 252 (1958).
[4] Holtz, P., Credner, K., and Koepp, W., *Arch. exp. Path. Pharmakol.*, **200**, 356 (1942).
[5] Schmiterlow, C. G., *Brit. J. Pharmacol.*, **6**, 127 (1951).
[6] Blaschko, H., *Biochim. Biophys. Acta*, **4**, 130 (1950).
[7] Mitoma, C., Posner, H. S., Bogdanski, D. F., and Udenfriend, S., *J. Pharmacol. Exp. Therap.*, **120**, 188 (1957).
[8] Armstrong, M. D., Shaw, K. N. F., and Wall, P. E., *J. Biol. Chem.*, **218**, 293 (1956).
[9] Boscott, R. J., and Bickel, H., *Scand. J. Clin. Lab. Invest.*, **5**, 380 (1953).
[10] Sjoerdsma, A., Lovenberg, W., Oates, J. A., Crout, J. R., and Udenfriend, S., *Science*, **130**, 225 (1959).
[11] Erspamer, V., and Glässer, A., *Brit. J. Pharmacol.*, **15**, 14 (1960).
[12] Carlsson, A., Lindqvist, M., Magnusson, T., and Waldeck, B., *Science*, **127**, 471 (1958).
[13] Murphy, G. F., and Sourkes, T. L., *Rev. Canad. Biol.*, **18**, 379 (1959).
[14] Mitoma, C., Posner, H. S., Reitz, H. C., and Udenfriend, S., *Arch. Biochem. Biophys.*, **61**, 431 (1956).

Reduction of Coenzyme Q by Succinic Acid Dehydrogenase

Crane, Hatefi, Lester and Widmer[1,2] have shown that coenzyme *Q* is reduced by mitochondria or derivative particles like electron-transporting particles, or succinic dehydrogenase complex, and that this reaction is sensitive to antimycin *A*. We have now succeeded in reducing coenzyme *Q* with a soluble preparation of succinic acid dehydrogenase, and this reaction was not sensitive to antimycin *A*.

Table 1. Reduction of Coenzyme *Q* by Succinic Acid Dehydrogenase

Assay conditions: 75 μM potassium phosphate, pH 7·2; 0·08 mgm. coenzyme *Q* in 0·02 ml. of anhydrous ethanol; 0·25 *M* sucrose to 1 ml. Incubation at 37°

Succinate (μM)	Enzyme (mgm.)	Duration of incubation (min.)	Inhibitor	Percentage of coenzyme *Q* reduced
7·5	0·1	10	None	20
7·5	0·2	10	,,	43
7·5	1·0	10	,,	86
7·5	0	10	,,	0
None	1·0	10	,,	0
7·5	0·45	2	,,	12
7·5	0·45	5	,,	18
7·5	0·45	10	,,	52
7·5	0·45	15	,,	77
7·5	0	15	,,	0
7·5	0·45	10	Antimycin *A* (30γ)	55
7·5	0·45	10	Antimycin *A* (60γ)	54
7·5	0·45	10	None	54
7·5	0·45	16	Antimycin *A* (30γ)	84
7·5	0·45	16	None	85

The enzyme was prepared from pig heart by the method of Neufeld *et al.* (preparation *B*, stage VI)[3]. The enzyme was dialysed at 0° against distilled water for 2 hr. The preparations showed succinic acid dehydrogenase activity, as measured by Slater's method[4], in the presence of methylene blue (12 µl. oxygen per mgm. of protein, per 60 min.), but did not exhibit any cytochrome *c* reductase and succinic oxidase activity. The reduction of coenzyme *Q* was determined by the method of Hatefi *et al.*[2]. The results are given in Table 1.

The results show that coenzyme *Q* is reduced by succinic acid dehydrogenase in the presence of succinate. Since this reaction is insensitive to antimycin *A*, it may be assumed that cytochrome *b* is not involved in this reaction.

A more detailed account of the experiments will be published in *Acta Biochimica Polonica*.

Józef Heller
Ludmiła Szarkowska
Czesława Petryszyn

Institute of Biochemistry and Biophysics,
Polish Academy of Science,
Warsaw.

[1] Crane, F. L., Hatefi, Y., Lester, R. L., and Widmer, C., *Biochim. Biophys. Acta*, **25**, 220 (1957).
[2] Hatefi, Y., Lester, R. L., Crane, F. L., and Widmer, C., *Biochim. Biophys. Acta*, **31**, 490 (1959).
[3] Neufeld, H. A., Scott, C. R., and Stotz, E., *J. Biol. Chem.*, **210**, 869 (1954).
[4] Slater, E. C., *Biochem. J.*, **45**, 1 (1949).

PHYSIOLOGY

Nervous Activity in Relation to the Respiratory Cycle

In the intact organism the physiological systems should show varying degrees of integration and interaction. Respiration is a cycle which appears likely to bear some relationship to moment-to-moment activity of the nervous system, because of its general biochemical effects, its wide afferent and efferent connexions, and its association with the brain stem reticular system. It is therefore relevant to ask whether changes in nervous activity occur preferentially in any part of the respiratory cycle. An answer can be sought in many facets of nervous function. In the electroencephalogram an abnormal feature very suitable for such study is the recurring, relatively stereotyped complex seen in sub-acute encephalitis[1] and possibly initiated from brain stem structures. A recent study in two cases[2] showed that these complexes arose preferentially at certain parts of the respiratory cycle; and the same obtained for eye blinks and voluntary movements. Further results reported here support the view that this asymmetrical distribution of activity is a more general phenomenon.

The object has been to determine the frequency of occurrence of a particular activity within each 1/10 of the respiratory cycle, a standard reference point on the activity being used for this analysis. The electroencephalogram, respiration and cardiogram were recorded simultaneously on 7, 8 or 16 channel apparatus in more than 40 patients undergoing neuropsychiatric investigation and in 12 normal adults. Respiration was measured unobtrusively with a thermocouple on the nose, and in some instances also by an expanding potentiometer on the chest. The respiratory ink traces showed distinct transition points at the onset of expiration, the interval between adjacent points being taken as a respiratory cycle. For analysis the respiratory tracing was obscured while standard reference points on the activity under study were marked on the trace. Each selected point was later projected on to its associated respiratory trace so that the 1/10 in which it fell could be determined, and frequency distributions compiled. The expiratory onset indicated by the thermocouple was probably not physiologically identical in all subjects or states of consciousness; but this seemed unlikely to produce misleadingly significant results. For statistical assessment the observed frequencies in the 10 intervals were compared (using chi square) with equal expectations at each interval. In each group subjects in which observation departed from expectation at the $< 0{\cdot}01$ level were considered individually; the sum of the data from the rest of the group was assessed in the same way after a preliminary chi square analysis to ensure that the figures to be summed did not differ significantly.

'Spontaneous' arousal activity of the *K* complex type was studied in 16 subjects in quiet barbiturate-induced or natural sleep under ordinary laboratory conditions, analysis being restricted to those complexes arising without any provoking sound recorded or noted at the time. A masking background noise was used in some instances. The total frequency distribution for the onset of 1,700 complexes appears in Fig. 1*A*. There are two distinct patterns—(*A*) those with a peak in the first 1/10, and (*B*) the remainder; and as seen from the figure these differ essentially by 1/10 phase. Statistically, for 3 subjects with large numbers of arousals, $P < 0{\cdot}01$; for the remainder summed, $P < 0{\cdot}01$.

Spindle activity arising apparently spontaneously under the same conditions was studied in 16 subjects. The onset was again used as the reference point, analysis being restricted to activity occurring as a generalized change. In Fig. 1*B* appear distributions for the total (4,530), and for the two divisions (*A*, *B*) split as for arousal activity. The patterns are less striking. Statistically, in 3 subjects $P < 0{\cdot}01$; and in the remainder summed $P < 0{\cdot}02$.

Spike and sharp wave activity in barbiturate-induced sleep in temporal lobe epileptics was studied similarly, but the analysis was complicated by the

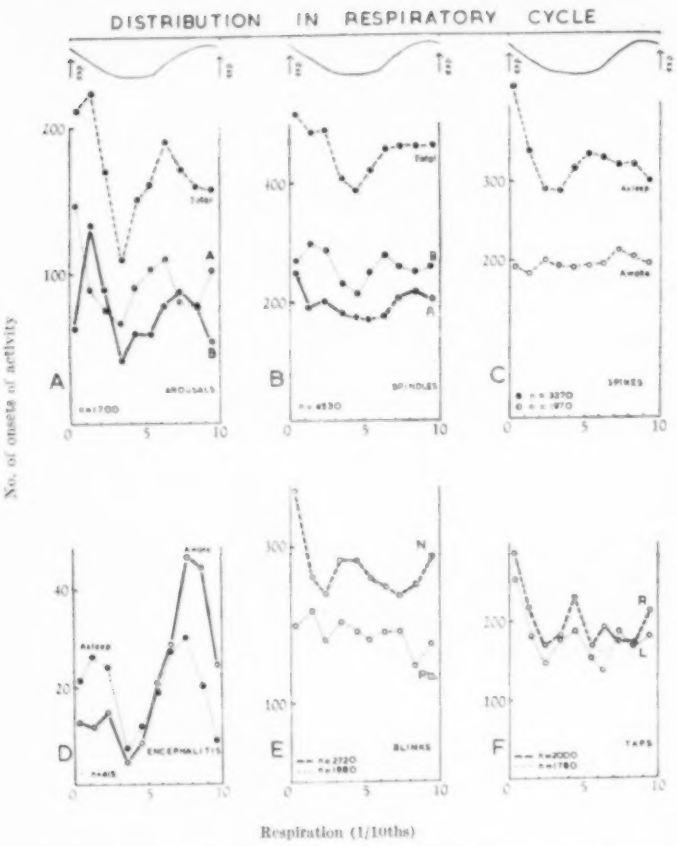


Fig. 1. Frequency of occurrence of events within each 1/10 of the respiratory cycle, taken as from the onset of one expiration (exp.) to the next. The events are the onset of: *A*, arousal activity; *B*, sleep spindles; *C*, spike/sharp wave activity; *D*, complexes in a case of sub-acute encephalitis; *E*, spontaneous blinking in normal adults (*N*) and patients (*Pts.*); *F*, voluntary tapping movements of the hands. (*n*, No. of observations. Total, 20,265)

tendency for the discharges to occur repetitively or in groups. Consistent results were obtained and the distribution of 3,270 discharges in 7 patients is seen in Fig. 1*C* ($P < 0{\cdot}001$). A tumour case provided a clear exception to this pattern. In the waking state there was no such uniform picture, as shown in Fig. 1*C* for 1,970 discharges in 7 patients.

In a case of sub-acute encephalitis the results obtained similarly for the onset of the complexes when awake and asleep are shown in Fig. 1*D* ($P < 0{\cdot}001$). Striking, though not identical, double-peak patterns have been seen in 2 other cases.

Spontaneous blinking was studied similarly in 8 normal adults unaware of the purpose of the investigation and free from visual distraction. Summed distribution for the onset of 2,720 blinks is shown in Fig. 1*E* (*N*). For 3 subjects $P < 0{\cdot}01$; for the summed remainder $P < 0{\cdot}02$. In 7 patients with more frequent blinking and some visual distractions the results were less uniform, as shown also in Fig. 1*E* (*Pts.*).

Voluntary repetitive tapping movements of the hand were studied similarly and the summed results for 10 subjects appear in Fig. 1*F* for right (*R*) and left (*L*) hands. The subjects were requested to tap every few seconds or so at will, preferably non-rhythmically, but without special attention; and the tapping was performed over long periods, interrupted by requests for pauses, changes of hand or frequency. All subjects were unaware of the purpose of the procedure and many that respiration was being recorded. For 2 subjects $P < 0{\cdot}01$; and for the remainder summed $P < 0{\cdot}001$. Fairly rapid rhythmic tapping in one demented and one defective patient showed only traces of this asymmetric distribution.

In natural sleep, dished or double-peak distributions were observed for the onset of slow activity in the presence of a tumour, and for slow activity leading on to spike discharges in focal epilepsy. Preliminary study of the suppression-burst activity of deep narcosis suggests an asymmetric distribution. Spike-and-wave type of epileptic activity showed in sleep a double-peak distribution which could be seen to some extent in the waking state, but not in all cases. A distribution similar to that for sub-acute encephalitis was seen in a lifelong epileptic with unusual recurring complexes associated with eyelid flutter. The double peak distribution may possibly be a basic pattern for some groups of activity. It might be noted that the respiratory distribution of heart beats (*Q* waves) has features in common with the above patterns when sinus arhythmia is present[2].

For any activity the distribution pattern depends on the frequency of repetition and the reference point chosen (changes in this latter producing a 'phase' or horizontal baseline shift). Nevertheless, patterns seen to a striking extent in sub-acute encephalitis are present to a lesser extent in other functions, though these are not necessarily independent of each other; for example, possibly the distributions of spike and spindle activity result from their association with arousal activity, which has much in common with encephalitic complexes. No methodological error has yet been found to account for these results. The possibility must be considered that the respiratory cycle reflects an influence which affects the probability of occurrence of many activities, an influence which, in the electroencephalogram, is best seen in sleep and certain pathological states where discharges may be initiated from brain stem structures. This influence, which need not be excitatory, might affect respiration or be secondary to it; and the reticular activating system would appear of first importance. It might impose a periodic tendency on otherwise sporadic activity, and influence the repetition interval or the likelihood of progression, for example, to a clinical attack. The termination and duration of activity are of interest in this type of study, which may assist the grouping of electroencephalogram phenomena.

Similar investigations of other aspects of nervous activity, for example, reflex and autonomic functions, are relevant.

E. W. Poole

Department of Clinical Neurophysiology,
Institute of Psychiatry,
London, S.E.5.

[1] Cobb, W. A., and Hill, D., *Brain*, **73**, 332 (1950).
[2] Poole, E. W., *EEG Clin. Neurophysiol.*, **12**, 759 (1960).

Changes in Mode of Respiration as an Indication of Level of Awareness

During a study of the peripheral autonomic electroencephalographic and psychological accompaniments of emotional states, it was discovered that frequently a change from thoracic to abdominal breathing, or vice versa, denoted more clearly than the electroencephalograph alone a change in the level of consciousness. The respiratory pattern was demonstrated by means of two expanding straps attached to potentiometer transducers, one around the abdomen and the other around the chest. The electroencephalograph, eye movements, galvanic skin resistance and peripheral vasomotor changes were also recorded, and there was a sound-level indicator.

In the upper example shown in Fig. 1 the subject is drowsy and snores are indicated. The mode of respiration is thoracic. Following a stimulus, the electroencephalograph shows arousal with a train of slow waves of high voltage. Accompanying this there is a change to abdominal breathing. In the lower part of the figure there is a shorter but similar arousal response and a change in the background activity of the electroencephalograph following a snore, but with a longer latency. The mode of respiration again changes to abdominal.

In Fig. 2*A* there is an apparently spontaneous arousal associated with an eye movement and a slight change to abdominal respiration. In Fig. 2*B*, following an external noise there is no arousal response in the electroencephalograph and no change in the background activity, but an eye movement initiates a clear change to abdominal breathing. In Fig. 2*C* there is again an apparently spontaneous arousal response in the electroencephalograph with no associated change in respiration, and to the right of the record a change in skin resistance (*PGR*) is followed by an electroencephalograph arousal and a change to abdominal respiration.

A consistent change in mode of respiration during sleep as a response to a sound stimulus could be used as objective evidence as to the site of the lesion in deaf children, and may be of value in distinguishing deafness from mental deficiency. It is likely that studies of the arousal system in man might be furthered by close study of associated respiratory changes and also the problems of 'adaptation' and 'apperception' in sleep.

We have observed when using hypnosis that a change in the mode of respiration occurs as the subject becomes hypnotized and that this can be used as the first indication of a change in the state of the subject when there is no other objective evidence. It has been observed that snoring can occur with every clinical appearance of sleep on the suggestion that

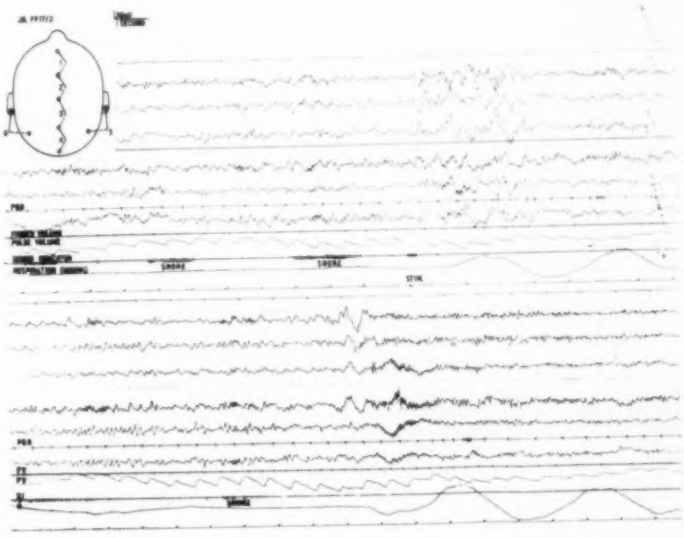


Fig. 1

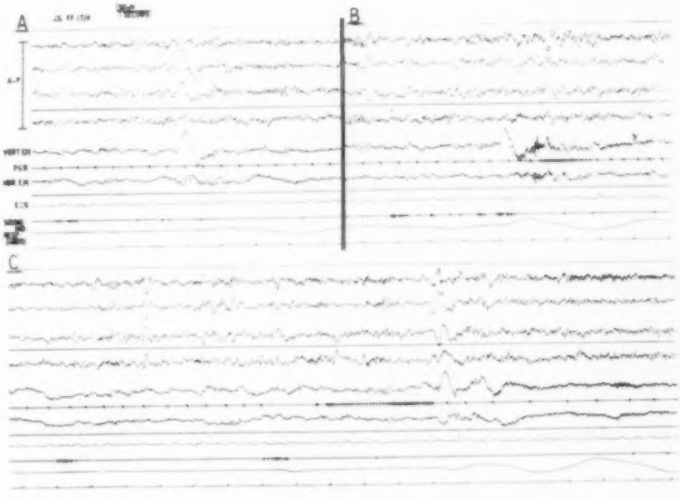


Fig. 2

the subject go to sleep, while the electroencephalograph remains that of the waking state.

L. Goldie
J. M. Green*

Institute of Psychiatry,
Maudsley Hospital,
Denmark Hill,
London, S.E.5.

* Supported by a grant from the Ford Foundation.

The Synchronous Discharge of Apocrine Sweat Glands of the Welsh Mountain Sheep

Evidence that from time to time the apocrine sweat glands of the Welsh Mountain sheep discharge their contents synchronously over a large area of the fleece-covered skin has emerged from the observation that thermocouples attached to the skin anywhere beneath the fleece simultaneously register an occasional and brief rise in temperature which frequently exceeds both ambient temperature and deep body temperature as measured by a thermocouple implanted within the brachio-cephalic trunk[1] (Fig. 1).

The rise in skin temperature cannot be attributed to a change in tissue conductivity, but could be due to the generation of heat at, or near, the surface of the skin, as might occur if an aqueous fluid were abruptly discharged from the skin and absorbed by the fleece, since the uptake of water by wool, which is hygroscopic, involves an exothermic reaction[2-4]. As there is a rise in the humidity of air drawn continuously through a cup attached to a shaved area of skin simultaneously with the rise in skin temperature beneath the fleece elsewhere on the body surface (Fig. 1), while no rise in skin temperature is detected by a thermocouple attached to another shaved area of skin, this appears to be the explanation for the phenomenon.

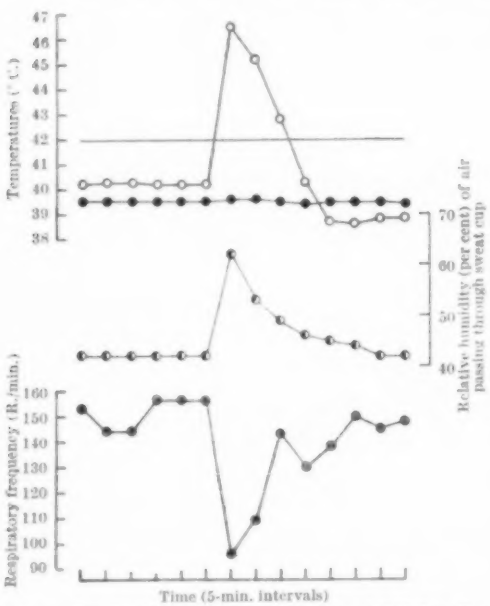


Fig. 1. The effect of a spontaneous discharge of fluid from the skin upon the skin temperature beneath the fleece (○), the relative humidity of air passing through a sweat cup (◐), respiratory frequency (□), and the temperature of the blood supply to the brain (●) at an ambient temperature of 42° C.

Table 1. Effect of Ambient Temperature on the Frequency of the Spontaneous Discharge of the Sweat Glands

Ambient temperature	Sheep No.	No. of 3-hr. exp.	No. of definite discharges	No. of possible discharges
20° C.	36	4	2	0
	37	6	0	0
	38	4	2	0
		14	4	0
42° C.	36	4	15	0
	37	6	10	6
	38	4	11	2
		14	36	8

The aqueous fluid is almost certainly derived from the apocrine sweat glands, of which there is one in association with each primary wool follicle[5], as it is known that the glands can be discharged by the administration of adrenaline (ref. 6 and Elliott, J. H., and Ferguson, K. A., personal communication), and the intravenous injection of 10–50 μgm. of adrenaline into a 25-kgm. sheep, under suitable conditions, will cause a similar rise in the temperature of the skin beneath the fleece. However, a second injection of adrenaline 30 min. later, or an injection of adrenaline shortly after a spontaneous discharge, may have only a small, or no, effect. This might be expected if the apocrine glands, following the expulsion of their contents by the contraction of the myoepithelium, are only slowly recharged by the secretory cells.

It is unlikely that the spontaneous discharge of the sweat glands results from a rise in blood adrenaline, as it is accompanied by a small depression (10–15 mm. mercury) in mean arterial blood pressure. A similar depression results from the intravenous injection of 3–5 μgm. adrenaline, but a larger quantity of adrenaline with a marked rise in blood pressure is generally necessary to discharge the sweat glands. The discharge stimulus may be mediated through a sympathetic innervation of the myoepithelium, as has been suggested for man[7].

The spontaneous discharge occurs with greater frequency at higher ambient temperatures (Table 1) but does not depend upon any rise in the temperature of the blood supply to the brain, and performs no obvious thermo-regulatory function. The Welsh Mountain sheep is generally able to maintain thermal equilibrium at an ambient temperature of 42° C. when evaporation is the only available channel of heat loss, whether or not there is a discharge of the sweat glands. Further, at high ambient temperatures, the mass discharge of the sweat glands is accompanied by a depression in respiratory frequency (Fig. 1) which more than compensates for any evaporation from the skin and may cause a small temporary rise in deep body temperature. A possible explanation for the greater frequency of discharges at higher ambient temperatures, which are accompanied by higher skin temperatures but not by a higher deep body temperature, is the local effect of heat on the secretory cells. An increase in the rate at which the secretion is formed would enable the glands to discharge more frequently.

A spontaneous mass discharge of the apocrine sweat glands followed by a quiescent period while the glands are being recharged does not appear to have been observed in other species with histologically similar

glands. The ox responds to high ambient temperature[8], and the horse responds to exercise[9], with what appears to be a continuous discharge of sweat, which may be due to a continuous process of secretion, or to the asynchronous discharge of the glands. However, human apocrine glands become refractory to further stimulation after they have been discharged by injected adrenaline[7,10], and it has been suggested that there are synchronous variations in the sweat rate of human eccrine glands, which may be due to the simultaneous contraction of the myoepithelium[11].

It has been claimed that sweating is an important channel of heat loss in sheep when exposed to high ambient temperatures[12–14], and the possibility of a background activity apart from the intermittent mass discharge of the sweat glands remains. However, more recent work[15–17] has shown that panting provides an adequate channel for evaporative heat loss and that sweat gland activity may be of little importance in temperature regulation.

While this synchronous discharge observed in the sheep is not a characteristic of apocrine sweat glands, it may be a characteristic of the more primitive organ from which these and other skin glands have evolved. The skin glands of frogs and mammary glands both respond synchronously to humoral stimuli, and the sweat glands of the sheep, which may serve little or no thermo-regulatory function, may represent a relatively primitive type of apocrine gland.

I am indebted to Mr. A. Barton for his scrupulous experimental assistance and to several colleagues for helpful discussions.

JOHN BLIGH

Agricultural Research Council
Institute of Animal Physiology,
Babraham, Cambridge.

[1] Bligh, J., *J. Physiol.*, **146**, 142 (1959).
[2] Hedges, J. J., *Trans. Farad. Soc.*, **22**, 178 (1926).
[3] King, G., and Cassie, A. B. D., *Trans. Farad. Soc.*, **36**, 445 (1940).
[4] Speakman, J. B., *Trans. Farad. Soc.*, **40**, 6 (1944).
[5] Carter, H. B., *Anim. Breed. Abstr.*, **23**, 101 (1955).
[6] Muto, K., *Mitt. med. Fak. Univers. Tokyo*, **15**, 365 (1916).
[7] Shelley, W. B., and Hurley, H. J., *J. Invest. Derm.*, **20**, 285 (1953).
[8] Ferguson, K. A., and Dowling, D. F., *Aust. J. Agric. Res.*, **6**, 640 (1955).
[9] Evans, C. L., Smith, D. F. G., and Weil-Malherbe, H., *J. Physiol.*, **132**, 542 (1956).
[10] Hurley, H. J., and Shelley, W. B., *J. Invest. Derm.*, **22**, 143 (1954).
[11] Nakayama, T., and Takagi, K., *Jap. J. Physiol.*, **9**, 359 (1959).
[12] Lee, D. H. K., and Robinson, K., *Proc. Roy. Soc. Queensland*, **53**, 189 (1941).
[13] Riek, R. F., Hardy, M. H., Lee, D. H. K., and Carter, H. B., *Aust. J. Agric. Res.*, **1**, 217 (1950).
[14] Knapp, B. J., and Robinson, K. W., *Aust. J. Agric. Res.*, **5**, 568 (1954).
[15] Brook, A. H., and Short, B. F., *Aust. J. Agric. Res.*, **11**, 402 (1960).
[16] Alexander, G., and Brook, A. M., *Nature*, **185**, 770 (1960).
[17] Hutchinson, J. C. D., Wodzicka, M., and Brook, A. H. (quoted by Brook and Short).

Influence of Calcium on the Potassium-Contracture of 'Slow' and 'Fast' Skeletal Muscle Fibres of the Frog

IT is well known that calcium is an important link in electromechanical coupling; however, there is little information about the underlying mechanism. Our knowledge about the action of calcium on the contracture of heart and skeletal muscles has been extended by a series of important observations[1–7]. Our experiments on electromechanical coupling have led us to investigate the action of calcium on tonic and twitch muscle fibres and to examine the problem whether the property 'slow' or 'fast' of a muscle fibre is influenced or caused by calcium.

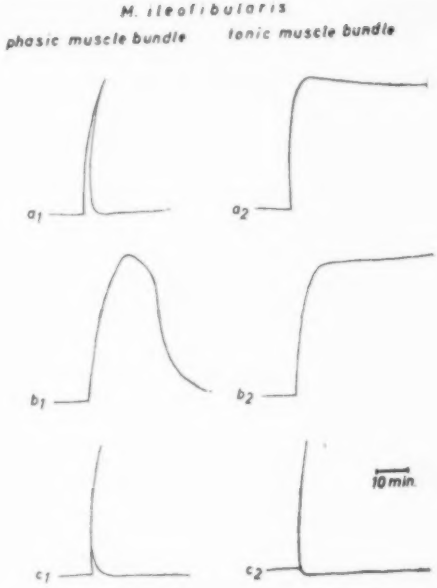


Fig. 1. Contraction (in isotonic potassium chloride solution) of fast (a_1 b_1 c_1) and slow (a_2 b_2 c_2) muscle-fibre bundles from m. ileofibularis of *Rana temporaria* after different preceding treatment (experiment from March 3, 1960). a_1 and a_2: fast and slow bundle after having been kept in normal Ringer's solution for 1 hr. before addition of potassium chloride. b_1 and b_2: these two bundles had been kept in isotonic, calcium-rich Ringer's solution for 1 hr. (88·0 m*M* sodium chloride; 2·5 m*M* potassium chloride; 18·0 m*M* calcium chloride). Potassium chloride solution in this case (93 m*M* potassium chloride, 18 m*M* calcium chloride). c_1 and c_2: These two bundles had been kept in isotonic, calcium-free Ringer's solution for 1 hr. (117·7 m*M* sodium chloride; 2·5 m*M* potassium chloride; 0·0 m*M* calcium chloride) before addition of potassium chloride

Fast and slow muscle fibre bundles from the m. ileofibularis (*Rana esculenta* and *R. temporaria*) were used for our experiments, the results of which are briefly discussed. Fig. 1*a* shows the typical reaction of a bundle of fast (a_1) and slow (a_2) muscle fibres to isotonic potassium chloride, that is, a rapid decline of the shortening of the twitch fibres and the prolonged contracture of the tonic ones.

Since the membrane potential is identical in both cases—it declines considerably and remains low—this means that there is a quick uncoupling of the process of contraction and depolarization in fast fibres, but this is not the case in slow fibres. Consequently there must be other governing factors. As is shown in the records reproduced in Fig. 1, this mechanism of coupling can be influenced by changing the calcium content of the Ringer's solution, which results in a more or less complete reversal of the specific function of either type of muscle fibre.

Curve b_1 shows the contracture due to potassium of a bundle of fast fibres after a preceding treatment with Ringer's solution of ten-fold calcium content. The reaction has become considerably more tonic. Even more pronounced is the effect of calcium on tonic fibres (curve b_2), which shows a higher and more prolonged contraction than that recorded in curve a_2. Finally, curves c_1 and c_2 show the effect of the absence of calcium on either type of muscle fibre: the contracture declines very rapidly.

This reversal of the function of fast and slow muscle fibres under the influence of varied calcium concentrations is not caused by a specific kind of membrane depolarization. It therefore seems to be the result of a direct action of the calcium on the mechanism of contraction.

The change in the contracting properties of fast and slow muscle fibres under the influence of varying calcium concentrations is not limited to contracture caused by potassium. It is also true for the so-called *Ermüdungskontraktur* and for the twitch. This will be discussed elsewhere.

The difference in the contractile properties of fast and slow muscle fibres suggests wide differences in the fundamental mechanism and ion kinetics.

Further investigations will be required to determine whether fast and slow muscle fibres have a different calcium content (probably through calcium pumps of different effectiveness), and whether the different resting potential (about 85 mV. for fast fibres; 60 mV. for slow fibres) inhibits the permeability of the tissue to calcium ions.

This work was described at a meeting of the German Physiological Association, Freiburg (Germany), on June 9, 1960.

P. Pauschinger
K. Brecht

Department of Physiology,
University of Tübingen,
Germany.

[1] Denton, E. J., *J. Physiol.*, **107**, 32, *P* (1948).
[2] Fleckenstein, A., and Hertel, H., *Pflüg. Arch. ges. Physiol.*, **250**, 577 (1948).
[3] Gilbert, D. L., and Fenn, W. O., *J. Gen. Physiol.*, **40**, 393 (1957).
[4] Lorković, H., *Amer. J. Physiol.*, **198**, 663 (1959).
[5] Lorković, H., *Amer. J. Physiol.*, **196**, 666 (1959).
[6] Löttgau, H. C., and Niedergerke, R., *J. Physiol.*, **143**, 486 (1958).
[7] Niedergerke, R., *Experientia*, **15**, 4, 128 (1959).

Distribution and Fate of Rose Bengal

It has been suggested[1] that complexity of the rose bengal plasma decay curve might be due to the uptake, by organs other than the liver, of different components of the dye. Björck *et al.*[2] and Meurman[3], using commercial rose bengal labelled with iodine-131, obtained results which made this assumption improbable and have interpreted the plasma decay curve by assuming the existence of a reverse flow of dye from liver cells into the blood.

In order to investigate this problem further, a pure component of rose bengal (B.D.H.) was separated by paper chromatography according to Ishida *et al.*[4]. This pure compound has a mauve-pink colour and is not fluorescent; by ascending paper chromatography it has an R_F value of about 0·42 and by descending a value of about 0·47. Maximal absorption of a 0·002 per cent solution was at 548 mμ while for the total dye it occurred at 540 mμ. Labelling with iodine was performed, with slight modifications, according to Liebster and Andrysek[5]. The isolated component contained 41 per cent of the total radioactivity and no free iodine-131 was detectable.

Using this purified labelled rose bengal it was found that the plasma decay curve in the rabbit was precisely the same as when using the original multi-component labelled rose bengal. This curve is approximately bi-exponential and closer examination shows that each of the two parts of the curve can be resolved into two exponential functions. The percentage disappearance-rates per min. in a typical curve had values of 28·9, 7·4, 1·2, and 0·11. It is concluded that the shape of the rose bengal plasma curve is not due to heterogeneity of the dye but solely to the biological situation.

Little information exists on extra hepatic uptake of rose bengal and no quantitative data are available[6–8]. The dye is bound by serum protein[9] and mostly by albumin[3]. Because trans-capillary passage of plasma protein takes place[10–13] it is likely that some extra-vascular diffusion of rose bengal will occur. It was found in normal rabbits that the amount of dye present in the extra-vascular space is not more than 3–4 per cent of the injected dose (60–80 μc. rose bengal labelled with iodine-131 in 5–10 mgm. carrier in 1–2 ml. of Ringer solution). This finding is supported also by the fact that in Meurman's data[3] about 6 per cent of the dose given is missing, and is most likely to be found in the carcass of the animal. By considering the size of the extra-vascular space[14], and the relative slowness of exchange[11], the later exponentials of the plasma decay curve appear to be explained.

Having to hand a single component of rose bengal it was thought worth while to see if the liver undertakes any biochemical conjugation of the dye as it does in the case of bromsulphalein[15]. Samples of rabbit bile, collected at different times following injection with labelled rose bengal, were subjected to ascending paper chromatography[4]. Only one radioactive spot with practically unmodified R_F value appeared for each sample, thus excluding transformation or conjugation of the dye. This agrees with the recent finding of Kubin *et al.*[16].

The fate of the albumin molecule after the removal of the rose bengal was also investigated. Rabbit albumin, prepared using carboxymethyl cellulose[17] and the elution gradient conditions indicated by Cohen[18], was labelled by the iodine monochloride method[19] with iodine-125 and then incubated with rose bengal labelled with iodine-131 (about 0·7

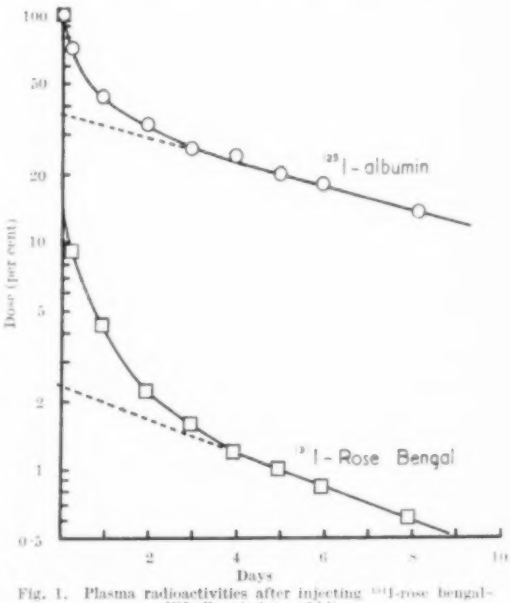


Fig. 1. Plasma radioactivities after injecting ^{131}I-rose bengal-^{125}I-albumin into rabbits

mole rose bengal per mole albumin). After dialysis at 2° C. against saline buffered with 0·01 *M* phosphate at *p*H 7·35, less than 0·5 per cent of the radioactivity was soluble in 10 per cent trichloracetic acid. The iodine-131-labelled rose bengal / iodine-125 labelled albumin complex was injected into two rabbits and radioactivities were measured in plasma, total body, urine and fæces. Fig. 1 shows that the iodine-131 label disappeared very rapidly from the circulation; it was found quantitatively in the fæces. The iodine-125 label, on the other hand, behaved exactly as it does when attached to normal rabbit albumin[20,21], that is, there was an initial disappearance of about half the albumin into the extra-vascular space and thereafter a steady exponential rate of loss occurred with half-lives of 130 and 140 hr. in the two experiments.

These experiments have demonstrated the lability of the dye–albumin complex and that the binding *in vitro* of rose bengal does not affect the catabolism of the albumin.

The advice and help of Dr. A. S. McFarlane and Mr. R. C. Holloway are gratefully acknowledged.

V. Bocci

National Institute for Medical Research, Mill Hill, London, N.W.7.

[1] Lima, F. W., and Picroni, R. R., *Nature*, **184**, 1065 (1959).
[2] Björck, G., Gardell, S., Carlberger, G., and Meurman, L., *Nature*, **185**, 847 (1960).
[3] Meurman, L., *Acta Med. Scand.*, **167**, Supp., 354 (1960).
[4] Ishida, Y., Inagaki, N., Shiota, A., and Watanabe, R., *J. Pharm. Soc. Japan*, **73**, 736 (1953).
[5] Liebster, J., and Andrysek, O., *Nature*, **184**, 913 (1959).
[6] Sapirstein, L. A., and Simpson, A. M., *Amer. J. Physiol.*, **182**, 337 (1955).
[7] Renault, H., Jacquier, C., Jammet, H., and Jammet, J., in "Radioisotopes in Scientific Research", **3**, 719 (Pergamon Press, London, 1958).
[8] Glaser, W., Gibbs, W. D., and Andrews, G. A., *J. Lab. Clin. Med.*, **54**, 556 (1959).
[9] Rosenthal, S. M., *J. Pharmacol.*, **25**, 449 (1925).
[10] Wasserman, K., and Mayerson, H. S., *Amer. J. Physiol.*, **165**, 15 (1951).
[11] Abdou, I. A., Reinhardt, W. O., and Tarver, H., *J. Biol. Chem.*, **194**, 15 (1952).
[12] Forker, L. L., Chaikoff, I. L., and Reinhardt, W. O., *J. Biol. Chem.*, **197**, 625 (1952).
[13] Dewey, W. C., *Amer. J. Physiol.*, **197**, 423 (1959).
[14] Krogh, A., *Acta Med. Scand.*, Supp., **90**, 9 (1938).
[15] Krebs, J. S., and Brauer, R. W., *Amer. J. Physiol.*, **194**, 37 (1958).
[16] Kubin, R. H., Grodsky, G. M., and Carbone, J. V., *Proc. Soc. Exp. Biol., N.Y.*, **104**, 650 (1960).
[17] Peterson, E. A., and Sober, H. A., *J. Amer. Chem. Soc.*, **78**, 751 (1956).
[18] Cohen, S., *S. Afr. J. Med. Sci.*, **23**, 245 (1958).
[19] McFarlane, A. S., *Nature*, **182**, 53 (1958).
[20] Cohen, S., Holloway, R. C., Matthews, C., and McFarlane, A. S., *Biochem. J.*, **62**, 143 (1956).
[21] Deichmiller, M. P., and Dixon, F. J., *J. Gen. Physiol.*, **43**, 1047 (1960).

HÆMATOLOGY

Inherited Hæmoglobin Ionographic Properties in Cotton Rats

A RECENT comparative study[1] showed that cotton rats (*Sigmodon hispidus*) were more variable, regarding hæmoglobin electromigration properties, than the other species examined. Several cotton rats of different hæmoglobin types were retained as breeders in order to investigate the genetic basis for these differences.

Hæmoglobin ionograms were obtained with Schleicher and Schuell 2043*A mgl* filter-paper strips in a Spinco Durrum type model *R* electrophoresis cell. The conditions of electrophoresis were as follows: 0·0225*μ* veronal buffer containing 15 per cent glycerol, *p*H 8·6, 20–26° C., 10 V./cm., 8 hr. duration. The dried strips were stained with bromphenol blue and were scanned in a Photovolt model 525 photoelectric densitometer.

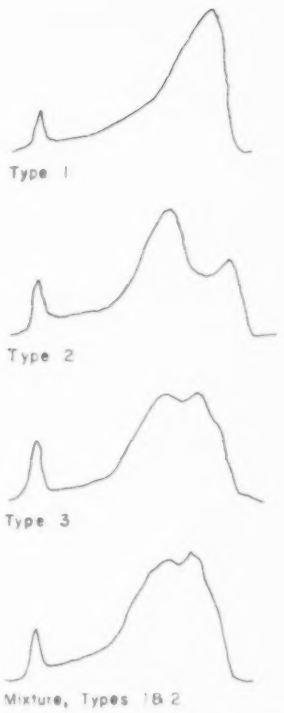


Fig. 1. Scanning curves of cotton rat hæmoglobin ionograms

Absorption scanning curves of the three different types of hæmoglobin ionograms found among cotton rats taken from wild populations are presented in Fig. 1. Among 23 cotton rats collected in Stanly County, North Carolina, 21 had hæmoglobin of type 2 and two had hæmoglobin of type 3. Of 11 cotton rats collected in Colquitt County, Georgia, seven had hæmoglobin of type 2, two had type 3, and two had type 1. Within the limits of resolution obtained, hæmoglobin type 1 seems to be a single component, but type 2 seems to contain two components, a major one plus a minor one of higher mobility. Type 3 is qualitatively indistinguishable, by this technique, from a 1 : 1 mixture of hæmoglobin types 1 and 2.

Protein that did not migrate from the origin is probably cellular debris that remained in the solutions after centrifugation. When hæmoglobin solutions were shaken with toluene or when centrifugation was prolonged these peaks did not appear; however, cotton rat hæmoglobins of all three types tended to precipitate from concentrated solutions, and omitting toluene extraction and shortening centrifugation time resulted in greater resolution.

In Table 1, cotton rat types *A*, *B* and *C* represent individuals that produce hæmoglobin types 1, 2 and 3, respectively. These results show that type *A* mated to type *B* produced only type *C* offspring. Type *C* rats mated to type *C* produced types *A*, *C* and *B*

Table 1. Cotton Rat Matings

Matings	No. of matings	Offspring			
		Type *A*	Type *B*	Type *C*	Total
B ♀♀ × *A* ♂	2	0	0	6 ♀♀ 2 ♂♂	8
C ♀ × *A* ♂♂	2	1 ♂	0	2 ♀♀ 2 ♂♂	5
C ♀♀ × *C* ♂♂	5	5 ♀♀	4 ♀♀ 3 ♂♂	6 ♀♀ 8 ♂♂	26
B ♀♀ × *C* ♂	2	0	4 ♀♀ 3 ♂♂	3 ♀♀ 2 ♂♂	12
					51

offspring in the approximate ratio 1 : 2 : 1, respectively. (A chi-square analysis of the actual ratio, 5 : 14 : 7, reveals that greater departures than this from the 1 : 2 : 1 ratio should occur by chance about 75 per cent of the time.) Type *A* mated to type *C* produced only types *A* and *C* offspring. Type *B* mated to type *C* produced only types *B* and *C* offspring. These findings plus the observation that 21 out of 23 rats taken at random in Stanly County, North Carolina, were type *B* (suggesting that type *B* cotton rats breed true) indicate that types *A* and *B* represent the homozygotes and type *C* the heterozygote of at least two contrasting genes. The fact that a 1 : 1 mixture of hæmoglobin from types *A* and *B* rats is almost indistinguishable from the hæmoglobin of type *C* rats suggests that these hæmoglobin genes act codominantly. The genes cannot be sex-linked, for heterozygotes may be of either sex. More data are needed, however, in order to ascertain whether the hæmoglobin locus in cotton rats is simple or complex.

I am indebted to the National Science Foundation for the support of this investigation.

Charles W. Foreman

Biology Department,
Pfeiffer College,
Misenheimer, North Carolina.

[1] Foreman, C. W., *Amer. Midland Nat.*, **64**, 177 (1960).

A New Inheritable Property of Human Sera : the InV Factor

Grubb and Laurell[1], Harboe and Lundevall[2] and Harboe[3] have described the serum groups Gma, Gmx and Gmb with the help of some rheumatoid-arthritic sera which were able to agglutinate O Rh + red cells sensitized with an incomplete anti-D. Also with an anti-D rheumatoid-arthritic serum complex, Steinberg and Giles[4] have discovered a new factor (Gm-like) only present in the Negro sera but absent in the Whites. Ropartz *et al.*[5] have demonstrated that some sera withdrawn from healthy donors could be used for the Gm groups typings : in fact, such sera sometimes possess a very pure anti-Gm specificity.

In particular, we studied one of these sera, Virm (the clinical examination shows no signs of arthritic diseases and the Waaler–Rose test is positive to 1/64). This serum, withdrawn from a blood donor, has the ability to agglutinate O Rh + red cells, coated by an incomplete anti-D. We could demonstrate that : (1) some normal sera were able to inhibit its agglutinating power ; (2) this inhibitory power is inheritable and dominant in regard to the non-inhibitory one ; (3) this inhibitory property is contained in the γ-globulin fraction (Burnstein's method) ; (4) its relation with the Gma, Gmb and Gmx factors is actually studied.

This new serum group is temporarily called InV. It is found in 18·52 per cent of the sera of our population chosen from Seine-Maritime, France. Of 324 individuals tested, 60 were found to be InV(+). The inheritance of this factor has been confirmed by the study of 34 matings yielding 74 children. Out of this family material, 25 families with both parents InV(−) had children who were all InV(−). The anti-D used for the red cells coating had the phenotype InV(+). We have found people InV(−) and InV(+) whatever their phenotype regarding the Gma, Gmb and Gmx may be. Hence it seems that this new factor is independent of these other factors. But further research is necessary to disclose a possible linkage. Besides testing 399 Negroes from Dakar we have found 214 of them to be InV(+), that is to say, 53·63 per cent. Among these Negroes, the InV factor has been found when the individuals were Gm-like(+) as well as Gm-like(−). Therefore it looks as if the InV factor is also independent of the Gm-like factor described by Steinberg and Giles. This fact seems to us to be of profound importance, since until now the Negroes have appeared to possess Gm factors quite different from those of Whites. For example, all the Negroes have the phenotype : Gm(a + b + x −)[6,7]. Moreover, the Gm-like factor is present only among them. On the other hand, the InV factor is found in the Negro sera as well as in the White sera.

C. Ropartz
J. Lenoir
L. Rivat

Centre Départemental de Transfusion Sanguine,
Rouen, Seine-Maritime.

[1] Grubb, R., and Laurell, A. B., *Acta Pathol. Microbiol. Scand.*, **39**, 390 (1956).
[2] Harboe, M., and Lundevall, J., *Acta Pathol. Microbiol. Scand.*, **45**, 357 (1959).
[3] Harboe, M., *Acta Pathol. Microbiol. Scand.*, **47**, 191 (1959).
[4] Steinberg, A. G., Giles, B. D., and Stauffer, R., *Amer. J. Human Genet.*, **12**, 44 (1960).
[5] Ropartz, C., Lenoir, J., Hemet, Y., and Rivat, L., *Nature*, **188**, 1120 (1960).
[6] Ropartz, C., Rivat, L., and Lenoir, J., *Rev. Franç. Etudes Clin. et Biol.*, **5**, 814 (1960).
[7] Steinberg, A. G., Boyer, S., and Stauffer, R., *Nature*, **188**, 169 (1960).

Delayed Hypersensitivity to Homologous γ-Globulin in the Guinea Pig

The existence in the rabbit of genetically determined antigenic differences ('allotypes') among homologous γ-globulins has been described by Oudin, who succeeded in preparing precipitating antisera against them after prolonged immunization with specific immune precipitates in adjuvants[1]. Considerable work has been done in an attempt to define the number of distinct serological groups and the number of genes controlling them in the rabbit[2]. The allotypic groups have been reported to be located on fragments I and II (as defined by R. R. Porter) of γ-globulin digested with papain[3].

Previous work on allotypes has been confined to the rabbit and to precipitating antibodies, with the exception of a statement by Oudin that he was able to observe some weak intraspecific precipitin reactions in guinea pigs[4]. In the present investigation, it is shown that guinea pigs, immunized with homologous γ-globulin in adjuvants, will rapidly develop a state of delayed hypersensitivity to the immunizing antigen, in the absence of antibody detectable by systemic anaphylaxis.

The experiments were carried out on white guinea pigs weighing 300–450 gm. In each experiment,

animals from a single breeder were used which, although not inbred, were fairly homogeneous. γ-Globulin was isolated from the sera of several coloured adult guinea pigs labelled *A*–*D*. Various procedures were used for isolation—salt fractionation, starch electrophoresis, chromatography—to ensure that the immune reactions observed could be attributed to the γ-globulin component of the serum. The following antigens were used:

Preparation I: guinea pig γ-globulin prepared from the serum of a coloured guinea pig by batch chromatography, by Dr. D. R. Stanworth, University of Birmingham (unpublished work).

Preparation II: guinea pig γ-globulin prepared from the serum of a coloured guinea pig, *D*, by starch electrophoresis.

Preparation III: guinea pig albumin from the same serum as preparation II, by starch electrophoresis. Preparations II and III were kindly prepared for these experiments by Dr. E. Franklin, New York University.

Preparation IV: guinea pig γ-globulin prepared from mixed sera of coloured guinea pigs *B*, *C*, *D* and *E*, by repeated precipitation with 16 per cent sodium sulphate at room temperature.

Preparation V (1–9): guinea pig γ-globulins prepared from sera of guinea pigs Nos. 17–25, by repeated precipitation with 16 per cent sodium sulphate.

Preparation VI (1–10): heat-denatured guinea pig γ-globulin prepared by heating sera of guinea pigs Nos. 26–35 at 63° C. for 10 min. and dialysing against distilled water at *p*H 6; the precipitate being spun off and taken up in saline.

The antigens diluted in isotonic saline were mixed with an equal volume of complete Difco adjuvant containing 2 mgm. *M. butyricum* per ml. and emulsified. The antigens were injected in a volume of 0·2–0·5 ml. The animals received two immunizing injections of 0·5 mgm. or less of homologous γ-globulin 8–9 days apart in the foot pads. The intradermal test injections were made in the flanks, in a volume of 0·1 ml. The reactions were observed at 2, 4, 6 and 24 hr. All reactions had the appearance and timing characteristic of delayed sensitivity and measured 8–25 mm. in diameter. They were graded as described elsewhere[5].

A series of animals were immunized with their own isolated γ-globulin, native or heat-denatured, to serve as controls (exp. 4). The presence of antibodies was investigated by testing for systemic anaphylaxis.

Irrespective of the method of preparation, immunization of guinea pigs with homologous γ-globulin induces a state of delayed sensitivity which can be observed 10 days after a single injection, but becomes better established after two injections, still in the absence of the anaphylactic state. No reactions are observed with autologous γ-globulin. The ease and rapidity with which guinea pigs can be made to show delayed sensitivity to homologous γ-globulin contrasts with the long time required to raise allotypic antibodies in the rabbit, and may provide a useful approach to the study of the genetic control of allotypes.

Although no attempts were made to investigate the number of allotypic groups in guinea pig γ-globulins, experiment 3 suggests that there are a number of such groups in this species, as there are in the rabbit.

It is not surprising that allotypes, which are weak antigens, give rise in the guinea pig primarily to delayed sensitivity, since in this animal species delayed sensitivity is an earlier and more sensitive immune response than is the formation of serum antibodies, especially after a weak antigenic stimulus[5–7]. It is possible that in man, having the capacity to show easily delayed sensitivity, this type of immune reactivity to homologous or denatured autologous serum proteins may play an important part in disease as a consequence of chance immunization.

Table 1. SEVERITY OF DELAYED INTRADERMAL REACTIONS IN GUINEA PIGS IMMUNIZED WITH HOMOLOGOUS OR AUTOLOGOUS γ-GLOBULIN

Experiment 1. Albino guinea pigs immunized with 0·2 mgm. homologous γ-globulin, Preparation I

Animal No.	Day 10	Day 14	Day 21	Day 28
	40 γgm. Prep. I	Boost	10 γgm. Prep. I	10 γgm. Prep. I
1	—		+ ±	+ + +
2	+ +		— + +	+ + +
3	+ ±		+	+
4	+	100 γgm.	+ ±	+
5	+ ±		+ ±	+ ±
6	+ +	Prep. I	+	+ +
7	+ + +		+ + +	+ + +
8	+ + —		+ + +	+ + +

Experiment 2. Albino guinea pigs immunized and boosted (day 9) with 0·5 mgm. homologous γ-globulin preparation II. Animals tested with preparation II and also homologous albumin preparation III.

Animal No.	Day 21	Day 22	Day 27	
	50 γgm. Prep. II	2 mgm. Prep. II intravenously (for anaphylaxis)	50 γgm. Prep. II	50 γgm. Prep. III (albumin)
9	+ + +	— ve	+ + +	—
10	+	— ve	+ + +	—
11	+ +	— ve	+ + +	—
12	+ + +	— ve	+ + +	—
13	+ +	— ve	+ +	—
14	+ + +	ve		—
15	+ + +	— ve	+ —	—
16	+ —	— ve	+ —	—

Experiment 3. 5 albino guinea pigs were immunized and boosted on day 8 with 0·5 mgm. of γ-globulin preparation IV (mixed γ-globulin from 4 guinea pigs *B*, *C*, *D* and *E*). They were tested on day 18 with 50 γgm. preparation IV and on day 20 with 1/50 dilution of the four individual sera *B*, *C*, *D* and *E*.

Animal No.	Prep. IV	Sera				Anaphylaxis, 2 mgm. Prep. IV: I-ven.
		B	*C*	*D*	*E*	
36	+	—		±	—	— ve
37	+ +	—	+	+	—	— ve
38	+ + ±	±		+ +	—	— ve
39	+ + ±	+ +	+ +	+ +	—	— ve
40	+ + +	+ +	+	+ + ±	+	— ve

Experiment 4. 9 guinea pigs, Nos. 17–25, were immunized and boosted on day 9 with 0·5 mgm. of their own autologous γ-globulin (preparation V, 1–9). These animals were tested intradermally on day 21 with 50 γgm. of the same preparations. No positive reactions occurred.

10 guinea pigs were immunized and boosted on day 9 with 0·5 mgm. of their own autologous heat-denatured γ-globulin (preparation VI, 1–10). When tested intradermally with 50 γgm. of the same preparation, 9 were negative, one showed a positive (+) delayed reaction, suggesting that autologous globulin could become antigenic upon denaturation. More work is being done to investigate this possibility.

B. BENACERRAF

Department of Pathology,
New York University College of Medicine.

P. G. H. GELL

Department of Experimental Pathology,
University of Birmingham,
Birmingham, 15.

[1] Oudin, J., *C.R. Acad. Sci., Paris*, **242**, 2489 (1956).
[2] Dray, S., and Young, G. P., *Science*, **129**, 1032 (1959). Dubiski, S., Skalba, D., Dubiska, A., and Kelus, A., *Nature*, **184**, 1811 (1959). Oudin, J., *C.R. Acad. Sci., Paris*, **250**, 770 (1960).
[3] Kelus, A., Marrack, J. R., and Richards, C. B., *Biochem. J.*, **76**, 13*P* (1960).
[4] Oudin, J., in *Symposium on Protein Structure*, 298 (Methuen and Co., Ltd., London, 1957).
[5] Benacerraf, B., and Gell, P. G. H., *Immunol.*, **2**, 53 (1959).
[6] Gell, P. G. H., and Benacerraf, B., *Immunol.*, **2**, 64 (1959).
[7] Salvin, S. B., *J. Exp. Med.*, **107**, 109 (1958).

RADIOBIOLOGY

Absorption of Inhaled Radioactive Water Vapour

The local function of different regions of the lungs can be studied by the inhalation of various gases labelled with oxygen-15. Recently, water vapour has been labelled in this way. Oxygen-15 has a half-life of 2 min. and is produced by a continuous flow process by bombarding nitrogen with deuterons in the Medical Research Council cyclotron in the grounds of Hammersmith Hospital. Details of its preparation have been published[1]. The oxygen-15 is available in nitrogen containing 3 per cent oxygen as carrier at a flow of 0·45 litre per minute. Radioactive water vapour was prepared by adding 4 per cent hydrogen in nitrogen at a flow of 1 litre per minute and passing the resulting mixture over a palladium-type catalyst ('Catalyst *D*'; Baker Platinum Co.). The effluent contained 2 per cent of water as a vapour and had an activity of about 10 mc. per litre. The absence of unconverted oxygen was checked with a mass spectrometer.

Three normal volunteers inhaled two breaths of 1 litre each from a plastic bag connected to a respiratory valve box and mouth-piece. The activity in the lungs and respiratory tract was detected by two pairs of scintillation counters connected in coincidence. Good spatial resolution can be achieved with this arrangement, 95 per cent of the counts coming from a cylindrical core of tissue 4 cm. in diameter, between two opposed counters. Random coincidences were automatically subtracted. The counting methods have been described elsewhere[1].

When the first breath was taken, the counters were arranged over the peripheral lung fields so that the clearance-rate at the alveolar level could be measured, but we were surprised to find that almost no active gas reached the alveoli. For subsequent breaths, the counter-pairs were moved about so that the counting fields included the mouth, pharynx, trachea and peripheral lung fields. Table 1 shows the counting-rates (corrected for radioactive decay) after a typical breath. It can be seen that much of the activity was found in the mouth and mid-trachea, little penetrated to the carina, but virtually none could be detected in the peripheral lung field.

Table 1. Counting-Rates after a Single Inspiration of Radioactive Water Vapour

Site of counting field	Counting-rate (counts/sec.)
Mouth (A.P.)	170
Pharynx (lat.)	120
Upper trachea (lat.)	160
Mid trachea (lat.)	100
Mid trachea (A.P.)	110
Carina (A.P.)	33
Right lung base (A.P.)	3

* The opposed counters were either in front of and behind (A.P.), or on either side (lat.) of the subject.

The rate of removal of the activity from the mouth area after a breath of the gas was measured by fixing a pair of counters at that level for 2 min. During this period, the counting-rate fell by a half, and since this corresponds to the natural decay-rate, the removal-rate must be slow compared with this.

The rapid removal of inhaled radioactive water vapour by the upper respiratory tract is readily explained by exchange with the water lining the tract, but the efficiency of this process is remarkable. The results are in keeping with the observation that 98–99 per cent of inhaled tritiated water vapour is absorbed[2], since this high figure could only be achieved if the anatomical dead space was cleared of the labelled gas. In this respect, radioactive water vapour is perhaps unique, as other gases undergo little exchange in the dead space, hence its name. The results also fit in with the rapid warming and humidification of inspired air in the upper respiratory tract which have been described[3].

An interesting feature of the preparation of the water vapour was the large loss of activity which occurred when the gas was led through about 10 metres of 0·5-cm. bore polyvinylchloride tubing connecting the chemistry laboratory with the investigation room. Under these conditions, the yield was up to ten-fold less than when the gas was collected in a rubber bladder attached to the end of the catalyst tube. This loss of activity can probably be explained by exchange with water absorbed on the surface of the connecting tube in spite of attempts to remove any moisture present by passing dry air through the tubing. Water absorption on surfaces is a common problem in vacuum technology.

We wish to thank Dr. P. Hugh-Jones for help, and the Director and Staff of the Medical Research Council Radiotherapeutic Research Unit for facilities. The work was supported by the Medical Research Council.

J. B. West
C. T. Dollery

Department of Medicine,
Postgraduate Medical School,
Hammersmith Hospital,
London, W.12.

[1] Dyson, N. A., Hugh-Jones, P., Newbery, G. R., and West, J. B., Second U.N. Conf. Peaceful Uses of Atomic Energy, Paper 278 (1958). Dyson, N. A., Hugh-Jones, P., Newbery, G. R., Sinclair, J. D., and West, J. B., *Brit. Med. J.*, I, 231 (1960).
[2] Pinson, E. A., and Langham, W. H., *J. App. Physiol.*, **10**, 108 (1957).
[3] Verzar, F., Keith, J., and Parchet, V., *Pflüg. Arch.*, **257**, 400 (1953).

Effect of Radioprotective Sulphydryl Compounds on the Oxygen Tension in the Spleen of Mice

In a previous paper[1] the mechanism of the radioprotective action of the biologically active amines histamine, epinephrine, tryptamine and β-phenylethylamine was investigated. In studying the effect of these compounds on the oxygen tension in the spleen and bone marrow of unanæsthetized mice strong evidence was obtained that a relation exists between the percentage protection against a lethal dose of X-rays afforded by these compounds and the degree of hypoxia caused in the blood-forming organs. Furthermore, it was shown[2] that cyanide also causes hypoxia in the spleen as a consequence of vasoconstriction and that this effect may well explain its protective action in mice.

In the present communication experiments are presented on the effect of a number of protective sulphydryl compounds on the oxygen tension in the spleen and bone marrow of unanæsthetized mice and rats.

The experiments were performed on groups of female *CBA/Rij* mice weighing 18–20 gm. and on male *WAG* rats of 180–200 gm.

Table 1. Changes in Oxygen Tension in the Spleen and Bone Marrow respectively of Unanæsthetized Female *CBA/Rij* Mice, 18–20 gm., and Male *WAG* Rats, 180–200 gm., caused by a Number of Prophylactics against Radiation. Neutralized Solutions of all Compounds were Injected Intraperitoneally in a Volume of 0·5 ml.

Species	Organ	Compound	No. of animals	No. of animals in each specified class				
				l.i.	*s.i.*	*n.e.*	*s.d.*	*l.d.*
Mouse	spleen	3 mgm. cysteamine	18	6	4	2	6	—
	femur	3 „ „	4	1	1	—	1	1 ?
	spleen	5 mgm. cystamine*	10	—	—	—	1	7 + 2 ?
	spleen	5 „ „ †	6	—	2	2	1	1
	spleen	7 „ „ †	4	—	—	—	1	3 (2 died)
	spleen	26·2 mgm. cysteine	6	1	2	1	2	—
	spleen	50 „ „	11	3	3	1	2	2
	femur	50 „ „	4	2	1	—	1	—
	spleen	75 „ „	1	—	—	—	—	1 (died)
	spleen	3 mgm. AET‡	5	4	—	—	1	—
	spleen	5 „ „	7	5	2	—	—	—
Rat	spleen	10 mgm. cysteamine	6	2	4	—	—	—
	spleen	20 „ „	11	5 + 2[1] + 1 ?	1	1[2]	—	1
	spleen	30 „ „	2	1	—	1	—	—
	femur	100 mgm. cysteine	2	1	1	—	—	—
	spleen	200 „ „	6	5	—	—	—	1
	femur	200 „ „	2	2	—	—	—	—
	femur	300 „ „	3	1	1	—	1	—
	humerus	300 „ „	6	4	—	—	1[3]	1
	spleen	400 „ „	6	—	1[4]	—	1[5]	3 + 1[6]
	spleen	500 „ „	2	—	—	—	—	2
	spleen	600 „ „	1	—	—	—	—	1 (died)

* Manufactured by Labaz, Bruxelles.
† Manufactured by California Foundation for Biochemical Research, Los Angeles.
‡ Amino-ethyl-*iso*thiuronium bromide.
? After *l.i.* or *l.d.* means that this condition was present for a short time only to change soon to *s.i.* or *s.d.*, respectively.
[1] Fairly soon followed by *s.d.* or *l.d.*
[2] After a considerable time *l.i.*
[3] Fairly rapidly thereafter *l.i.*
[4] Followed by *s.d.*

The technique of the polarographic estimation of the oxygen tension in the spleen has been described elsewhere[1]. In addition the oxygen tension in the bone marrow of the femur in mice and of the femur and humerus in rats was estimated by a similar method.

The results were found to vary considerably within each experimental group. The different types of response obtained after injection of the protective compounds were divided so far as possible in five classes as follows: *n.e.*, either no effect or a rise or fall not exceeding 10 per cent of the pre-injection value; *s.i.*, a slight increase in oxygen tension between 10 and 40 per cent; *l.i.*, a larger increase exceeding 40 per cent; *s.d.*, a slight decrease between 10 and 40 per cent; *l.d.*, a larger decrease exceeding 40 per cent.

The results of the experiments are represented in Table 1, in which the number of animals belonging to each class is indicated for a number of protective compounds used in doses which were found to protect the animals against a lethal dose of total body irradiation with X-rays. In a number of cases the classification failed, which is indicated in Table 1.

Table 1 shows that in contrast to the effect observed after both the biologically active amines and potassium cyanide the effect of the sulphydryl compounds is subject to considerable variation. However, for most of the compounds studied the oxygen tension shows a tendency to rise rather than to fall. Cysteine at higher (just sub-lethal) doses only causes a decrease in oxygen tension.

A possible exception is cystamine, to which most of the animals react with hypoxia. This is in accordance with the view[2] that cystamine, being devoid of a free sulphydryl group, acts like a biologically active amine. The fact that amino-ethyl*iso*thiuronium bromide behaves like the sulphydryl compounds is consistent with the view that it is converted into mercapto-ethyl-guanidine[4].

In summary, these results strongly indicate that the protection afforded to mice by the sulphydryl compounds is not mediated by hypoxia of the blood-forming organs. Therefore their mechanism of action differs from that of the biologically active amines and cyanide.

A number of investigators have expressed the view that sulphydryl compounds have a protective effect other than the production of anoxia. The most recent observations are the experiments of Lothe and Devik[5] on the rabbit ear, those of Kohn and Gunter[6,7] on *Escherichia coli*, of Grant and Vos[8] on isolated rat thymocytes and of Vergroesen *et. al.*[9] on HeLa cells in tissue culture.

C. van der Meer
P. W. Valkenburg
M. Remmelts

Medical Biological Laboratory,
RVO-TNO,
Rijswijk, Z.H.,
The Netherlands.

[1] Meer, C. van der, and Bekkum, D. W. van, *Int. J. Rad. Biol.*, **1**, 5 (1959).
[2] Meer, C. van der, and Valkenburg, P. W., *Acta Physiol., Pharmacol. Neerl.*, **9**, 324 (1960).
[3] Bacq, Z. M., and Herve, A., *Schweiz. Med. Wschr.*, **82**, 1018 (1952).
[4] Shapira, R., Doherty, D. G., and Burnett, W. T., *Rad. Res.*, **7**, 22 (1957).
[5] Lothe, F., and Devik, F., *Acta Radiol.*, **44**, 306 (1955).
[6] Kohn, H. J., and Gunter, S. E., *Rad. Res.*, **11**, 732 (1959).
[7] Kohn, H. J., and Gunter, S. E., *Rad. Res.*, **13**, 250 (1960).
[8] Grant, G. A., and Vos, O., *Int. J. Rad. Biol.* (in the press).
[9] Vergroesen, A. J., Budke, L., and Vos, O., *Int. J. Rad. Biol.* (in the press).

Changes in Radioresistance of Sporulating Cells of *Bacillus cereus*

The spores of bacilli represent a unique form of living matter capable of surviving many harmful factors of environment and of restoring intense metabolic activity under suitable conditions. The

study of individual mechanisms of resistance of spores was directed mainly to the differences in the content of individual constituents of cytoplasm of spores and of vegetative cells.

One of the typical differences between vegetative forms and spores is the different cystine content. Hot trichloracetic precipitate of spores of some bacilli which have been studied contains about 4–5 times as much as this amino-acid as the vegetative cells[1–3]. On the basis of incorporation of cysteine labelled with sulphur-35 and calcium chloride labelled with calcium-45 during sporulation of *Bacillus cereus* on liquid medium, it was observed that the maximum incorporation of sulphur-35 appears about 2 hr. earlier than the maximum incorporation of calcium-45. The period of increased incorporation of calcium-45 is accompanied by the thermostabilization of structure of spores[3]. This observation is in accordance with the data from literature in which calcium bound with dipicolinic acid is assumed to be the main factor of thermoresistance of spores of bacilli[4–8].

The period of the formation of cysteine-rich structure precedes slightly the formation of the refractile structure of spores. A question arises whether the cystine structure contributes in some way to the resistance of spores. With regard to the possible importance of cystine in radioprotection, the resistance of sporulating cells of *Bacillus cereus* (NCIB 8122) to X-rays was examined. A liquid medium containing tryptic casein hydrolysate (0·3 per cent), glucose (0·1 per cent) and traces of some ions was used for cultivation, free spores having been used as inoculum. A vibration stirrer (100 oscillations/sec., amplitude 1 mm.) was used for splitting of chains, normally formed in this strain, and for homogeneous distribution of the air introduced into cultivation vessel. Practically only pairs of cells were present during the stationary phase of cultivation. Continually harvested samples of culture diluted with *M*/40 phosphate buffer to adequate concentration ($1:10^5$) were irradiated by Machlett *AEG-50-T* röntgen ray tube (50 kV., 40 m.amp., 0·1 mm. aluminium) in dishes (diam. 23 mm.) equipped with electromagnetic stirrers. On the basis of inactivation curves of vegetative cells and of free spores of this strain of *Bacillus cereus*, the radiation dose corresponding to 120 kr. was chosen. For detection of the loss of thermosensitivity of sporulating cells the aliquots were heated to 65° C. for 15 min. The number of surviving forms was determined in either case by plating procedure, non-treated suspension being used as control. As a recovery medium Difco nutrient agar was used. The percentage of spores was determined by direct microscopic observation and counting. The term 'refractile spores' is used for the more or less refractile areas of cytoplasm of the size and shape corresponding to spores, with somewhat diffuse rim. Cystine content was determined in acid hydrolysates of hot trichloracetic precipitates[2] by means of Shinohara's method[9] using phospho-18-tungstic acid.

The results are given in Fig. 1. They show that the radioresistance of sporulating cells appears simultaneously with the formation of cystine structures. Appearance of radioresistance is closely followed by the formation of refractile structure. The thermostabilization proceeds only after the fully refractile structure has been formed. With regard to the presence of pairs of cells in the culture, the results should be accepted as rather qualitative

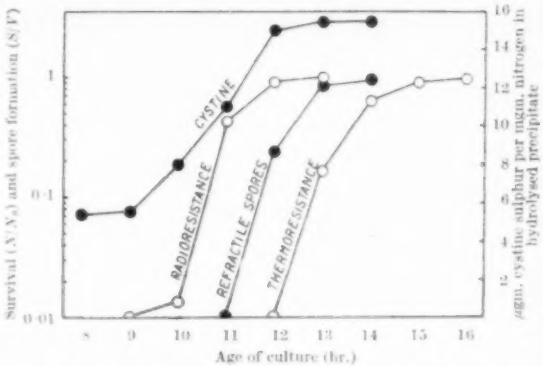


Fig. 1. Changes in radioresistance, cystine content and thermosensitivity of sporulating cells of *Bacillus cereus*. *N*, No. of surviving pairs of cells; N_0, No. of all pairs present; *S*, No. of cells with spores; *T*, No. of all cells present

than quantitative. The correlation observed, however, between appearance of radioresistance and formation of cystine structure seems to be important.

Practically no cysteine has been found; only cystine is present in hot trichloracetic precipitates of spores of bacilli[3]. As the presence of disulphide linkages can be expected in proteins of spores, mention should be made of the role of this bond in radioprotection. According to results of paramagnetic resonance studies of X-irradiated proteins[10–12] the disulphide bond seems to have the function of a powerful electron donor. Whenever in proteins the electron is knocked out by ionizing radiation the vacancy created is assumed to be filled by an electron borrowed from a cystine group. The formation of mixed disulphides with protein SH—groups was demonstrated with typical radioprotective agents such as cystamine, cysteamine, etc.[13], and the radioprotective efficacy of these compounds is directly correlated to their ability to form disulphides[14]. It can, therefore, be expected that even in spores the disulphide groups play a prominent part in radioprotection of proteins. The cystine-rich protein structure, being localized in the integumental fraction of spores[3], can serve as a carrier for some important enzymes which were observed to be attached to the envelopes of spores[15,16].

Vladimír Vinter

Department of Microbiology,
Institute of Biology,
Czechoslovak Academy of Science,
Prague.

[1] Vinter, V., *Nature*, **182**, 998 (1959).
[2] Vinter, V., *Fol. Microbiol.*, **4**, 216 (1959).
[3] Vinter, V., *Fol. Microbiol.*, **5**, 217 (1960).
[4] Powell, J. F., *Biochem. J.*, **54**, 210 (1953).
[5] Perry, J. J., and Foster, J. W., *J. Bacteriol.*, **69**, 337 (1955).
[6] Powell, J. F., and Strange, R. E., *Biochem. J.*, **63**, 661 (1956).
[7] Halvorson, H. O., *J. Appl. Bact.*, **20**, 305 (1957).
[8] Church, B. D., and Halvorson, H., *Nature*, **183**, 124 (1959).
[9] Shinohara, K., *J. Biol. Chem.*, **112**, 671 (1936).
[10] Gordy, W., Ard, W. B., and Shields, H., *Proc. U.S. Nat. Acad. Sci.*, **41**, 983 (1955).
[11] Gordy, W., and Shields, H., *Rad. Res.*, **9**, 611 (1958).
[12] Gordy, W., and Miyagawa, I., *Rad. Res.*, **12**, 211 (1960).
[13] Eldjarn, L., and Pihl, A., *J. Biol. Chem.*, **225**, 499 (1957).
[14] Eldjarn, L., and Pihl, A., *Rad. Res.*, **9**, 110 (1958).
[15] Powell, J. F., and Hunter, J. R., *Biochem. J.*, **62**, 381 (1956).
[16] Berger, J. A., and Marr, A. G., *Bacteriol. Proc.*, 41 (1957).

HISTOCHEMISTRY

Effects of Nitrogen Mustard on the Histochemistry of Mouse Lymphocytic Leukæmia *L* 1210

THE possibility of detecting chemical (histochemical) changes prior to discernible morphological changes in leukæmic cells following chemotherapy and the attempt to determine the emergence of cellular resistance to a given chemotherapeutic agent provide the basis of the present work.

Isotransplants of acute lymphatic leukæmia (*L* 1210)[1] and sub-lines resistant to 8-azaguanine developed in the Battelle Memorial Institute by the use of 8-azaguanine[2] in *DBA* and *DBF*1 hybrid mice were employed. A total of 80 animals were examined during the course of this work. An inoculation of 0·2 ml. of diluted peritoneal fluid made to approximately 100,000 cells was injected intraperitoneally into host mice; survival-time was between 8 and 9 days after inoculation. Peritoneal fluid was obtained on the 8th day and routine films and supravital preparations prepared. Immediately following this step the animals were injected with 0·05 mgm. nitrogen mustard in 0·1 ml. of distilled water (an *LD*50 for a 20-gm. mouse)[3]. At 15 min. and 1 hr. following injection samples of peritoneal fluid were withdrawn from each animal and films prepared. Each animal served as its own control, and additional controls were used consisting of intraperitoneal injections of 0·1 ml. of distilled water.

The following histochemical methods were employed: (1) the DDD method for protein-bound sulphydryls[4]; (2) the indoxyl acetate method for non-specific esterase[5]; and the periodic acid–Schiff method for 1,2 glycols. Routine Wright's stained films and supravital preparations examined with the phase microscope were used for morphological evaluation.

The lymphocytic cells exhibited a strong reaction for sulphydryls localized in their cytoplasm, nucleoplasm and chromatin (Fig. 3). However, very occasionally morphologically intact lymphocytic cells were observed in the peritoneal fluid, which exhibited appreciably less reactivity for sulphydryls than the vast majority of leukæmic cells in the specimen (Fig. 4). In most instances, within 15 min. following the injection of nitrogen mustard there was a marked reduction in reactive sulphydryls present in all leukæmic cells (Fig. 5). This change in the sulphydryl reactivity occurred before the first morphological signs of cellular damage (Figs. 1 and 2), which usually appeared between 1 and 1½ hr. after the administration of the drug. The sulphydryl reactivity of the leukæmic cells present in one of the leukæmic sub-lines resistant to 8-azaguanine appeared less than that observed in the leukæmic cells in the non-resistant strains and other 8-azaguanine-resistant sub-lines. These cells too revealed a reduction in sulphydryl reactivity following nitrogen mustard, although the apparent degree of reduction was less than in the non-resistant strains. Esterase activity demonstrable in the lymphocytic cells with the indoxyl acetate method appeared to increase following the administration of nitrogen mustard. Increased activity as compared with controls was noted at both the 15-min. and 60-min. periods after therapy. Glycogen was not demonstrable in the leukæmic lymphocytes, although a few saliva-resistant periodic acid–Schiff-positive granules were present in their cytoplasm. Periodic acid–Schiff reactivity did not change following injection of nitrogen mustard.

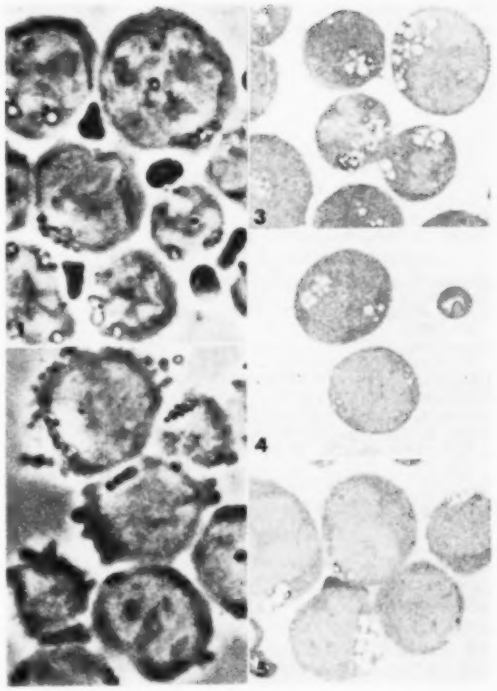


Fig. 1. Lymphocytic cells from peritoneal fluid. Non-resistant strain of mouse lymphocytic leukæmia *L* 1210. Control specimen. Phase contrast microscopy. Reduced from × 3,000

Fig. 2. Lymphocytic cells 1 hr. following intraperitoneal injection of nitrogen mustard. Note cytoplasmic budding. Phase contrast microscopy. Reduced from × 3,000

Fig. 3. Lymphocytic cells from non-resistant strain of mouse lymphocytic leukæmia *L* 1210. Control specimen. Note the strong sulphydryl reaction of these cells. DDD method for protein-bound sulphydryl. Reduced from × 3,000

Fig. 4. Similar to Fig. 3 except the lower cell exhibits a weaker sulphydryl coloration than the upper lymphocytic cells or those in Fig. 3. DDD method for protein-bound sulphydryl. Reduced from × 3,000

Fig. 5. Lymphocytic cells 15 min. following intraperitoneal injection of nitrogen mustard. Note the decrease in sulphydryl reactivity as compared with control specimen (Fig. 3). Reduced from × 3,000

This preliminary study indicates that chemical changes do occur and occur quite rapidly in mouse leukæmia cells of the *L*1210 strain following nitrogen mustard therapy. Certain histochemically demonstrable changes were noted in the leukæmic cells following nitrogen mustard and before apparent morphological alteration. The possibility of nitrogen mustard binding to available sulphydryl groups present in the leukæmic cells[6,7] seems likely, and may be the mechanism accounting for the decreased sulphydryl reaction given by these cells following nitrogen mustard. The possibility of histochemically distinct sub-lines of leukæmia and the possibility of histochemically detectable resistant cells in cell populations of non-resistant strains warrant further detailed study.

We wish to acknowledge the Battelle Memorial Institute for providing the animals employed in this investigation.

The investigation was supported by research grant *H*-4061 from the National Institutes of Health, Bethesda 14, Md.

George J. Furman
G. Adolph Ackerman
Carl Cohen

Department of Anatomy,
Ohio State University,
Columbus, Ohio,
and
Battelle Memorial Institute,
Columbus, Ohio.

[1] Dunham, L. J., and Stewart, H. L., *J. Nat. Cancer Inst.*, **13**, 1299 (1953).
[2] Law, L. W., and Boyle, P. J., *Proc. Soc. Exp. Biol. and Med.*, **74**, 599 (1950).
[3] Anslow, jun., W. P., Karnowsky, D. A., Jager, B. V., and Smith, H. W., *J. Pharm. and Exp. Therap.*, **91**, 224 (1947).
[4] Ackerman, G. A., and Sneeringer, S. C., *Lab. Invest.*, **9**, 356 (1960).
[5] Ackerman, G. A., *Lab. Invest.*, **9**, 298 (1960).
[6] Roberts, J. J., *Ann. N.Y. Acad. Sci.*, **68**, 722 (1958).
[7] Stacey, K. A., Cobb, M., Cousens, S. F., and Alexander, P., *Ann. N.Y. Acad. Sci.*, **68**, 682 (1958).

Steroid-3β-ol-Dehydrogenase Activity in Fœtal Leydig's Cells

There is a considerable quantity of evidence demonstrating that the fœtal testis produces a hormone responsible, for example, for the freemartin effect[1]. Explantation of fœtal rat testes has shown that secretion of the hormone begins when the fœtus is 15–16 days old[2,3]. Morphological differentiation of the Leydig cells begins during the same period, the interstitial spaces being filled by closely packed polygonal cells containing periodic-acid–Schiff-positive material[4].

Although morphological observations thus favour the view that rat's Leydig cells are active and secreting from the third intra-uterine week, there is a lack of direct evidence for the presence in the testis of steroids or other substances leading to androgen formation.

In the work reported here a histochemical method[5] was used for the demonstration of steroid-3β-ol-dehydrogenase activity in the fœtal interstitial cells of the rat testis. This enzyme has been shown to play a basic part in the formation of the non-benzenoid steroid hormones[6]: consequently, its activity in the testis can be taken as an indicator of the hormone synthesis in it.

Female rats on heat were mated for 2–4 hr. Fœtuses were removed at intervals from 15 days after the mating, and either the whole fœtuses or their abdominal parts were rapidly frozen. Fresh sections were cut at 25μ with a cold microtome and stained with hæmatoxylin and eosin. Subsequent sections were incubated for the demonstration of the dehydrogenase activity. Dehydro*iso*androsterone in a concentration of 0·03 mgm./ml. served as the substrate and sections were incubated at 37° C. for ½–1 hr.

A positive dehydrogenase reaction was obtained in the rat fœtal testis from the fifteenth day of fœtal life. The interstices of the testes could then be identified with reasonable accuracy. In these, groups of cells giving a positive dehydrogenase reaction could be observed (Fig. 1). The sex cords did not show any enzyme activity at all. The formazan precipitate was finely granular in the round polygonal cells of the interstitial spaces, but a diffuse reddish diformazan staining of the interstices was also constant.

From the fifteenth day of pregnancy to a few hours after birth the histochemical reaction for steroid-3β-ol-dehydrogenase remained qualitatively similar, but quantitative changes could be noticed. The interstitial cells became more numerous and more closely packed, and, hence, the positive formazan deposition was more pronounced (Fig. 2). Formazan was still in the interstitial cells as a granular precipitate, and the germinal epithelium remained unstained. No certain increase in the intensity of staining of the individual Leydig cells towards birth could be observed. A positive dehydrogenase reaction occurred also in the Leydig cells of testes of rats killed a few hours after birth. There, the sex cords comprised a relatively larger portion of the testicle than during the fœtal life, and the positive interstitial cells were correspondingly more separated; but the dehydrogenase activity was otherwise unchanged in its localization and intensity.

The present observations give histochemical support to earlier findings of hormonal activity of the fœtal testes. It is of special interest to note that the steroid-3β-ol-dehydrogenase activity was found to continue from the fifteenth day to birth without any obvious changes in the enzyme activity in the individual Leydig cells, although the relative volume and number of these cells much increased during this period.

It has been proposed[4] that the different morphological appearance of pre- and post-natal Leydig cells would indicate different modes of secretion before and after birth. Our present findings show, however, that there is at least one important enzyme catalysing the synthesis of steroid hormones common in fœtal as well as in adult rat testicles. This does not, of course, prove that the fœtal testicular product was identical with the adult testicular hormone[7].

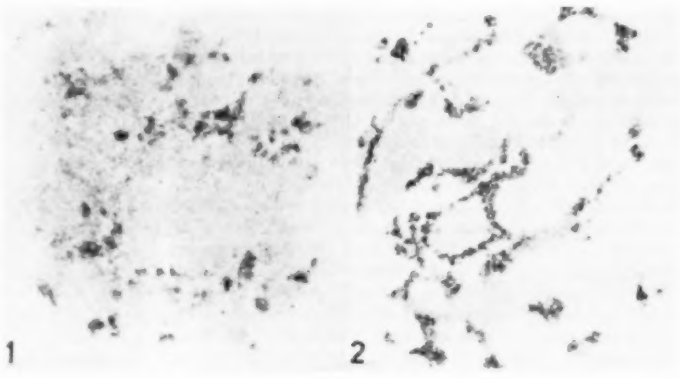


Fig. 1. Steroid-3β-ol-dehydrogenase activity in the testis of a rat fœtus, fifteenth day of fœtal age. Granular formazan deposits are visible in the interstitial spaces; the sex cords are unstained. (× c. 127)

Fig. 2. Testis of a fœtus of the eighteenth day. The Leydig cells are more numerous and further differentiated; the enzyme activity is clearly localized in the interstitial cells only. (× c. 77)

Looking for traces?

MERVYN-HARWELL
SQUARE WAVE POLAROGRAPH
Mark III

A basic scientific advance in the field of Analysis, Testing and Quality control.

Whether you are "*Looking for Traces*" in processing Metals or Foodstuffs, carrying out research on Gas or Petroleum, or linking quality-testing with production processes, you should invest in the MERVYN-HARWELL SQUARE WAVE POLAROGRAPH

- Analyses minute quantities.
- Extremely sensitive.
- Exceptionally selective.
- Completely self-contained.
- Versatile, Adaptable.
- Operators need not be specialists.
- Strikingly convenient, mobile.
- Controls located and ganged for rapid, accurate operation.
- Built-in cell, thermostat.
- Deoxygenated supply and recorder.
- Reversible and irreversible reactions.
- Resolves 20 mv.

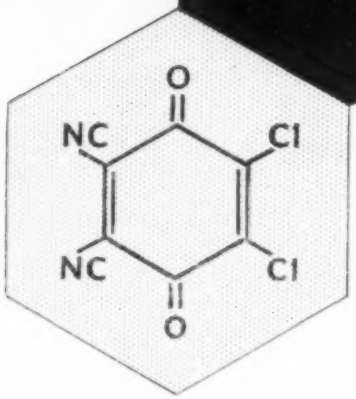
Write for further information, mentioning "Nature" to:

MERVYN INSTRUMENTS

WOKING · SURREY · ENGLAND · *WOKING 5200*

D·D·Q*

(2:3 - DICHLORO - 5:6 - DICYANO - *p* - BENZOQUINONE)



for the efficient

dehydrogenation of partially aromatic ring systems[1];

oxidation of allylic alcohols to the corresponding $\alpha\beta$-unsaturated ketones[2];

conversion of 3-oxo-Δ^4- and 3-oxo-$\Delta^{4,6}$-steroids to the corresponding 1-dehydro-derivatives[3].

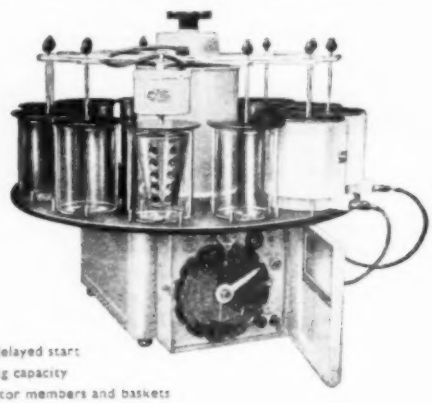
1. Braude, Linstead and collaborators, *Nature*, 1952, 169, 100: *J. Chem. Soc.*, 1954, 3569, et seq.: *Chem. & Ind.*, 1954, 1174.
2. Burn, Petrow and Weston, *Tetrahedron Letters*, 1960, No. 9, 14.
3. Burn, Kirk and Petrow, *Proc. Chem. Soc.*, 1960, 14

. . . is offered for the first time by BDH

THE BRITISH DRUG HOUSES LTD. B D H LABORATORY CHEMICALS DIVISION **POOLE · DORSET**

FOR PERIODS UP TO
1 hour
24 hours
7 days

The *Histokinette* stays on the job



Diagnostic reports to hand hours earlier than they would be with manual processing and in far greater numbers—the release of a valuable technician for other duties . . . these are the outstanding advantages of the Histokinette Automatic Tissue Processing machine. Once the Histokinette has been put into operation, it will *without supervision* go through the entire cycle of fixation, dehydration, impregnation in wax, or alternatively can be set up for the washing or staining of tissues. It can handle large numbers of specimens at the same time and while staff is off duty—speed up almost any technique by ensuring quicker and more thorough penetration by reagents.

A 24-hour clock is fitted as standard. Change over to 1 hour or 7 day cycles (*the latter of great value in double embedding and bone decalcification techniques*) is simple and rapid.

Histokinette special features include:—

- Up to 24 hours delayed start
- Double processing capacity
- One or more motor members and baskets
- Unbreakable tissue basket and containers

The Hendrey Histokinette is in general use at home and overseas

. . . to quote a few in U.K.

Aberdeen	Edinburgh	Newcastle-on-Tyne
Belfast	Glasgow	Newport
Birmingham	Greenock	Nottingham
Bristol	Hereford	Sheffield
Canterbury	Liverpool	Swansea
Cardiff	Llanelly	Torquay
Dundee	London	
	Manchester	

. . . and some of our exports

Argentine	Eire	Mexico
Australia	Egypt	New Zealand
Belgium	Finland	Nicaragua
Brazil	France	Norway
Canada	Ghana	S. Africa
Ceylon	Holland	Singapore
Chile	India	Sweden
China	Israel	Switzerland
Cuba	Italy	Thailand
Denmark	Japan	

Hendrey Relays

Write for illustrated brochure

HENDREY RELAYS LTD., BATH ROAD, SLOUGH, BUCKS. Tel. Burnham 609/611
MANUFACTURING ELECTRICAL ENGINEERS CONTROL & LABORATORY APPARATUS
Sole Export Distributors: Measuring and Scientific Equipment Ltd., Spenser Street, London S.W.1

This work has been supported by a grant from the Sigrid Jusélius Stiftelse to one of us (M. N.).

MIKKO NIEMI
M. IKONEN

Department of Anatomy,
University of Helsinki,
Siltavuorenpenger,
Helsinki.

[1] Moore, K. L., Graham, M. A., and Barr, M. L., *Anat. Rec.*, **118**, 442 (1955).
[2] Jost, A., *Arch. Anat. Micr. Morph. Exp.*, **39**, 577 (1950).
[3] Price, D., and Pannabecker, R., Ciba Foundation Colloquia on Ageing, **2**, 3 (1952).
[4] Roosen-Runge, E. C., and Anderson, D., *Acta Anat.*, **37**, 125 (1959).
[5] Levy, H., Deane, H. W., and Rubin, B. L., *Endocrinol.*, **65**, 932 (1959).
[6] Samuels, L. T., and Helmreich, M. L., *Endocrinol.*, **58**, 435 (1956).
[7] Benirschke, K., and Bloch, E., *Acta Endocrinol.*, **34**, 65 (1960).

PATHOLOGY

Mast Cells and Fibrinolysin

DURING the investigation of human tissues for fibrinolytic activity the presence of a fibrinolytic substance was detected in a specimen of a spleen. This was a case of splenic mastocytosis previously reported[1] in which there were many mast cells and a high concentration of histamine and heparin in the splenic tissue.

We investigated eighteen fresh samples of human spleens obtained at autopsy for the presence of plasminogen activator and plasmin-like activity using the selective and quantitative methods of Astrup, Mullertz[2] and Albrechtsen[3]. The fibrinolytic activity was recorded by measuring the diameter in sq. mm. of the products of tissue potassium thiocyanate extracts on standard bovine fibrin plates (heated and unheated). According to this method, the unheated bovine fibrin plates are reactive to both plasminogen activators and plasmin-like substances, whereas the heated plate reacts only to plasmin. It thus becomes possible to distinguish between plasminogen activators and plasmin or plasmin-like activity.

Potassium thiocyanate extracts of eighteen samples of eighteen different human spleens were assayed for fibrinolytic activity. Of the eighteen splenic extracts, only four showed some activity on heated and unheated plates but this activity was never equal to or greater than that activity of the mastocytotic spleen discussed in the above-mentioned case. Since the spleen containing mast cells had been kept frozen for more than a year when tested for fibrinolytic activity, it was felt that further work would be necessary to evaluate properly this fibrinolytic property.

It was decided to conduct additional studies on various tissues including mast cell tumours in dogs. All the dog tumours had portions removed for pathological examination. These were examined by haematoxylin and eosin stain and special stains for mast cells such as luna, toluidine blue and Bismarck brown.

All potassium thiocyanate extracts of dog mastocytomas reacted on unheated plates. On heated plates these extracts possessed little or no activity. One of the cases, a mast cell sarcoma, showed more tissue activator activity than any other tissue examined by us up to date. The tissue activator was found in varying amounts in dog tumours which contain little or no mast cells.

A different pattern of fibrinolytic activity emerged when carefully weighed samples of mast cell tumour tissue were placed on heated and unheated bovine fibrin plates[4,5]. All primary samples of mastocytoma tissue reacted on heated and unheated plates. It was interesting to note that the second and third recurrence of a mast cell sarcoma failed to lyse the heated fibrin plates. No other tumour, whether it was benign or malignant, lysed the heated fibrin plate. These observations are reported in Table 1.

Table 1. FIBRIN PLATES

Type of dog tumour	Unheated	Heated
Mast cell sarcoma		
Original	+ + +	+
First recurrence	+ + +	+ +
Second recurrence	+ + +	neg.
Third recurrence	+ + +	neg.
Malignant melanoma	+ +	neg.
Mast cell tumour	+ + +	+ + +
Mast cell tumour	+ + +	+ +
Myosarcoma	neg.	neg.
Breast fibro adenoma	+ +	neg.
Perianal gland adenoma	neg.	neg.

In accordance with interpretations of the above findings, it appears that these mast cell tumours contain a plasmin-like substance which dissolves both heated and unheated plates.

A study was made of the intracellular distribution of the fibrinolytic activity of the mast cell sarcoma noted in Table 1. Tissue activator was found in the low-speed sediment, the mitochrondrial and microsomal fractions. There was little or no activity associated with the soluble fraction. The microsomes contained the greatest concentration of tissue activator. A significant amount of plasmin-like activity was associated with the low-speed sediment.

This work was supported in part by Grant No. *H*4135 from the Division of Research, National Institutes of Health.

NORMAN ENDE
JOSEPH V. AUDITORE
Clinical Laboratory and Research Laboratory
of the Veterans Administration Hospital,
Nashville, Tennessee,
and
Departments of Pathology and Medicine,
Vanderbilt University,
Nashville, Tennessee.

[1] Ende, N., and Cherniss, E. I., *Blood*, **13**, 631 (1958).
[2] Astrup, T., and Mullertz, S., *Arch. Biochem.*, **40**, 346 (1952).
[3] Astrup, T., and Albrechtsen, O. K., *Scand. J. Clin. Lab. Invest.*, **9**, 233 (1957).
[4] Astrup, T., and Permin, P. M., *Nature*, **159**, 681 (1947).
[5] Permin, P. M., *Nature*, **160**, 571 (1947).

Pyridine Nucleotide Metabolism in Heliotrine Poisoning

IT has been claimed[1] that failure of activity of a group of pyridine nucleotide - linked respiratory enzymes is an important factor in the acute hepatotoxic action of the alkaloid heliotrine, a member of the pyrrolizidine (*Senecio*) group. The respiratory effect occurred between 16 and 20 hr. after administration of the dose, and reactivation of the non-respiring mitochondria was obtained by addition of diphosphopyridine nucleotide (DPN) to the incubation medium.

Direct estimation of DPN and DPNH in liver homogenates of rats injected intraperitoneally with 320 mgm./kgm. body-weight of heliotrine was carried out by the alcohol dehydrogenase method[2], and a progressive fall to one-half of control values occurred over the period critical for respiration (Table 1). The assay method was not sufficiently sensitive for reliable determinations of mitochondrial DPN, although considerable reduction was observed over the same period.

Table 1. Mean Values (μgm./gm. wet weight) of Liver Homogenates of Rats treated with Heliotrine at Various Times Prior to Killing compared with Controls

Control	Heliotrine-treated		
	10 hr.	17 hr.	24 hr.
350	300	235	175

The possibility that heliotrine might reduce the capacity of the liver to synthesize pyridine nucleotides was therefore investigated. Initially, the DPN pyrophosphorylase activity of isolated nuclei[3,4] from control and heliotrine-treated rat liver was measured[5], and showed a definite but minor fall (Table 2).

Table 2. Comparative Rates of DPN Synthesis by Liver Nuclei from Control and Heliotrine-treated Rats (μmole DPN/hr./10^9 Nuclei)

Animal	11 hr.	15 hr.	19 hr.
Control	23·1	22·7	21·7
Heliotrine-treated	19·4	17·5	13·1

Inasmuch as *in vitro* conditions, with optimum concentrations of substrate, might not reflect the full extent of an *in vivo* reduction of DPN synthesis, the degree of increase of liver DPN after injection of nicotinamide[6] was determined with control and heliotrine-poisoned animals. In the strain of Wistar rats used, an injection of 500 mgm. nicotinamide/kgm. body-wt. raised liver DPN several fold within 4 hr., to a limiting value which was maintained for many hours (Table 3).

Table 3. Effect of Nicotinamide (500 mgm./kgm. body-weight) on Liver DPN (μgm./gm. wet weight). Each Value is a Mean of Determinations on Three Different Animals

Control	Nicotinamide-treated			
	4 hr.	8 hr.	12 hr.	18 hr.
285	810	1,015	1,020	915

With the animals pretreated with heliotrine, the ability to respond to a nicotinamide injection was depressed (Table 4), supporting the results with isolated nuclei (Table 2).

Table 4. Mean Liver DPN-Levels (μgm./gm. wet weight) 4 hr. after Nicotinamide Injection in Rats pretreated with Heliotrine. Times refer to Duration of Heliotrine Treatment prior to Killing Animal

Control	Heliotrine-treated				
	4 hr.	14 hr.	18 hr.	20 hr.	24 hr.
810	750	715	580	545	375

In further experiments in which heliotrine-treated animals were given repeated injections of nicotinamide prior to killing, thus maintaining homogenate concentrations of DPN above normal values, the mitochondria failed to oxidize citrate, α-oxoglutarate and β-hydroxybutyrate unless DPN was added to the Warburg flasks. Chelating agents were ineffective.

Thus, although heliotrine produced a definite reduction of DPN synthesis at the 14–24 hr. period, this effect was not great enough to account for the complete failure of pyridine nucleotide - linked respiration observed at this time, and which still occurred even when homogenate DPN values were maintained above normal levels by administration of nicotinamide.

These observations support the hypothesis that failure of cell respiration in heliotrine poisoning is due to inability of the mitochondria to maintain effective local DPN-levels at enzymatically active foci, rather than to reduction of pyridine nucleotide synthesis.

This investigation was supported by a research grant from the Anti-Cancer Council of Victoria.

G. S. Christie
R. N. LePage
Margot J. Bailie

Department of Pathology,
University of Melbourne.

[1] Christie, G. S., *Aust. J. Exp. Biol.*, **36**, 413 (1958).
[2] Kaplan, N. O., Ciotti, M. M., and Stolzenbach, F. E., *J. Biol. Chem.*, **221**, 833 (1956).
[3] Branster, M. V., and Morton, R. K., *Biochem. J.*, **63**, 640 (1956).
[4] Hogeboom, G. H., and Schneider, W. C., *J. Biol. Chem.*, **197**, 611 (1952).
[5] Kornberg, A., *J. Biol. Chem.*, **182**, 779 (1950).
[6] Kaplan, N. O., Goldin, A., Humphreys, S. R., Ciotti, M. M., and Stolzenbach, F. E., *J. Biol. Chem.*, **219**, 287 (1956).

ANATOMY

Properties of Stressed Bone

During the past two years I have been investigating experimentally and histologically the relationship between stresses upon the skull, especially its sutures, caused by and transmitted through the masticatory apparatus.

The animals used in these experiments were the common South African vervet, *Cercopithecus aethiops*, and the stresses applied on the intact heads of the dead monkeys were by means of many ordinary elastic bands stretched around the skull and mandible.

Sections taken through various suture systems and the tooth-bearing parts of the jaws were fixed in 5 per cent formo-saline and decalcified in nitric acid. The sections were then treated with several of the conventional stains, including Masson's stain.

The pattern of green, reddish-brown and the mixture of these colours was so bizarre that it appeared at first to be completely random; but repeated instances of alterations in the colour from green to reddish-brown were found to be systematically recurring in the bones. They occurred according to whether or not stress had been applied to or transmitted through the bone, in that particular region.

When Masson's stain combination is applied to a section of unstressed bone the calcified tissue stains green. If the section passes through an area stressed in the manner stated above the colour of the stressed region is found to be reddish-brown.

The regularity of this localized colour change was noted and then Nicol's prism demonstrated that the normally green staining bone does not transmit light, but that the stressed reddish-brown staining bone now transmits light. Clearly a fundamental physical change had accompanied this profound alteration in staining reaction.

Lest the stain itself should be responsible for the physical change, serial sections of the same specimen were examined for birefringence. Both unstained sections and those stained with hæmatoxylin and eosin (which display no such colour differentiation as exhibited by the Masson-stained specimens) are found still to demonstrate the birefringence caused by the preceding stress.

Sections of the neurocranial bones, which have not been stressed experimentally prior to preparation and Masson's staining, sometimes show an outer plate to which muscles are attached and which exhibit a reddish-brown staining accompanied by birefringence while the inner table is almost entirely green. Where the inner table happens to be reddish-brown it too is birefringent.

Similar changes in the birefringence and staining properties of stressed bone have also been demonstrated in the long bones of vervet monkeys. This indicates that the changes brought about *in vitro* probably also occur *in vivo*. If so, these physical changes in bone must be reversible and perpetually recurring according to the stresses exerted by external forces such as those applied experimentally here or by forces such as those which are developed during muscular activity.

This communication has been prepared to direct attention to some of the changes that occur in bone as a result of being stressed. These changes may have an important bearing on the growth and repair of bone.

C. J. Dreyer

University of the Witwatersrand and
Council for Scientific and Industrial Research,
Johannesburg.

BIOLOGY

Transfer of Tolerance to Skin Grafts in F_1 C57Bl Inbred Mice

Co-existence of adult animals in experimental parabiosis is followed in due time by 'immunological neutralization' as revealed in tolerance to reciprocal skin grafts. Nakic and Silobrcic[1] observed in rats of different breeds that even after 5 days of parabiotic union homografts survived a longer time than in control animals. Skowron-Cendrzak and Konieczna-Marczyńska[2] reported that the skin homografts of white, non-related mice 'took' permanently after seven weeks of parabiosis. Rubin[3] and Martinez *et al.*[4] found parabiotical neutralization in hybrids of two inbred mice-strains united with individuals of one of the parental breeds. The survival-time of grafts of separated mice parabionts depends upon the length of time of parabiotic union. Similarly, it has been possible to obtain with the help of parabiosis permanent skin isografts in mice characterized by the strong sex-antigen which normally counteracts successful male skin transplantation to the female[5,6]. The duration of parabiosis necessary to evoke neutralization depends upon the degree of antigenic differences between the united individuals. It was shown that in *C57Bl* inbred mice which only differ in sex-antigen, skin grafts from the male to the female performed one week before union may already 'take' permanently[7].

The mechanism of neutralization has not yet been fully elucidated and can be conditioned by such different factors as trauma, enhancement, immuno-paralysis and immunological unresponsiveness in adults. The induction of tolerance takes place only if the vascular connexion between the joined animals is established, and a constant reciprocal exchange of a great quantity of antigens exists. In long-term parabiosis between the individuals of two inbred strains of mice (*CBA,A*) in which neutralization was lacking, there was never any vascular connexion between parabionts (unpublished work).

The purpose of the work reported here was to establish whether the tolerance to male skin isografts acquired in females during parabiosis can be transmitted to the F_1 generation.

Mice of the inbred *C57Bl* strain imported by our Department three years ago from the Institute of Animal Genetics, Edinburgh, served as material. Parabioses were carried out, always uniting females with isologous males (sisters with brothers). The animals were 4–6 weeks old. One week after the establishment of parabioses, skin grafts were exchanged between the respective members of each parabiotic pair. Whole-skin grafts taken from the back measuring 2 cm. × 2 cm. and rotated 180° were kept in place by sutures. All skin isotransplants were successful. After 1–10 weeks the parabionts were separated and kept in pairs in order to obtain the F_1 generation.

Out of thirty-four F_1 females on which, at the age of 4 weeks, the male brother skin was transplanted, in two cases the grafts were accepted permanently. These grafts were held until the death of the animals (133 and 140 days respectively). In all other females (32) the great majority of isografts survived significantly longer than in controls ($t = 4{\cdot}51$; $P < 0{\cdot}01$). The end of the survival-time was taken to be when the first signs of incompatibility reaction appeared. The control group consisted of fifty *C57Bl* females, 4–6 weeks old, on which the skin taken from isologous male donors of the same age was transplanted. In fourteen females, 2–3 weeks after the first graft, the second-set grafts from the same males were performed. A much shorter survival-time of the second-set grafts corroborates the results obtained by Eichwald *et al.*[8] and reveals the immunological nature of the graft rejection.

The results of isotransplantation in control as well as in experimental mice are shown in Table 1.

Table 1. Survival-Time (days) of ♂ to ♂ Skin Isografts in Strain *C57Bl* Mice

Group		No. of animals	Range	Mean	Standard deviation
Control	First graft	50	12–18	15	± 1·5
	Second graft	14	6–11	7·6	± 1·3
Experimental	First	32	14–49	21	± 9·1

In transmission of tolerance to the F_1 generation the duration of union of parental individuals plays no part. This is evident from the fact that permanent acceptance of the male skin grafts was observed in one of the F_1 females of which the parents had only been united during one week. Similarly, the length of time after separation of parabionts probably has no influence on the transmission of tolerance. The second female, permanently tolerant to the male skin graft, belonged to the animals of the F_1 generation, which were born not earlier than 8 months after the separation of the parabionts. From one and the same parental pair and even from only one individual of them, females can be born which are either completely tolerant, incompletely tolerant or which reject male skin within the same period of time as the control animals do.

At present further experiments are being carried out on isografts of the F_1 and F_2 generation in order

to elucidate both the mechanism of parabiotic neutralization and the mechanism of tolerance transmission.

Anna Skowron-Cendrzak

Department of Experimental Zoology,
Polish Academy of Sciences,
Kraków, Kopernika 7,
Poland.

[1] Nakic, B., and Silobrcic, V., *Nature*, **182**, 264 (1958).
[2] Skowron-Cendrzak, A., and Konieczna-Marczyńska, B., *Folia Biologica, Krakow*, **7**, 95 (1959).
[3] Rubin, B. A., *Nature*, **184**, 205 (1959).
[4] Martinez, C., *et al.*, *Proc. Soc. Exp. Biol. and Med.*, **103**, 266 (1960).
[5] Mariani, T., *et al.*, *Proc. Soc. Exp. Biol. and Med.*, **101**, 596 (1959).
[6] Skowron-Cendrzak, A., and Konieczna-Marczyńska, B., *Nature*, **184**, 1590 (1959).
[7] Skowron-Cendrzak, A., and Konieczna-Marczyńska, B., *Folia Biologica, Krakow*, **8**, 71 (1960).
[8] Eichwald, E. I., *et al.*, *Ann. N.Y. Acad. Sci.*, **64**, 737 (1957).

Perfect Stages of *Fusarium oxysporum* and of *Fusarium solani* f. *pisi* still Unknown

A year ago Buxton[1] reported the development of red, *Nectria* perithecia after ultra-violet irradiation of a culture of *Fusarium oxysporum* f. *pisi* (Linf.) Snyd. and Hans. He stated that the fungus causes typical wilt of pea, was re-isolated from the reddened vascular tracts of wilted plants and that, therefore, there could be little doubt but that this homothallic *Nectria* is the perfect stage of that particular wilt-inducing *Fusarium* isolate (that is, *F. oxysporum* f. *pisi*).

Recently, Gordon[2] has taken issue with Buxton's claim, pointing out quite clearly and correctly that *Nectria* (=*Hypomyces*) is well known as a perfect stage of some clones of *F. solani* (Mart.) App. and Wr. emend. Snyd. and Hans., but that for various reasons it would not be expected as a perfect stage of *F. oxysporum*.

We have examined a culture of Buxton's fungus, containing the *Nectria* perfect stage, which had been deposited with the Commonwealth Mycological Institute at Kew. We find that this fungus is a typical, homothallic *Hypomyces solani* Rke. and Berth. emend. Snyd. and Hans. (=*Nectria haematococca* Berk. and Br.), as diagnosed by the Commonwealth Mycological Institute, and Gordon, and has as its imperfect stage *Fusarium solani*. Repeated single-spore cultures made by us of both the ascospores and conidia from the Buxton culture yielded the same, homothallic species. Perithecia developed abundantly within two weeks after transfer and required only diffuse daylight for their initiation and maturation. In these respects we are in agreement with Gordon, and likewise we have not found *F. oxysporum* in the culture, just *F. solani*. These two species are very distinctive and readily differentiated in culture. Over a period of decades during which these two fungus species have been studied, no conclusive evidence has been presented, either of overlapping of the species or of their common *Hypomyces* origin.

Gordon[2] has expressed the opinion that Buxton did not have *F. oxysporum* f. *pisi* but rather *F. solani* f. *pisi* (Jones) Snyd. and Hans., and postulated that the perfect stage in *Hypomyces* (=*Nectria*) which Buxton reported is that of *F. solani* f. *pisi*. Further, that since the perfect stage of this pathogen is unknown, Buxton's report represents the first record of its occurrence.

We do not agree with Gordon's postulation. We have run two separate inoculation tests in the greenhouse on two varieties of pea. In these tests three fungi were used: Buxton's isolate, a similar homothallic *Hypomyces solani* indirectly obtained from the Rothamsted area, England, some ten years ago, and a local isolate of *F. solani* f. *pisi*. Inoculations were made by applying spore suspensions to pea seedlings growing in pots of sterilized soil. In both tests, run at different times, the plants inoculated with Buxton's fungus, the Rothamsted fungus, and the uninoculated controls were completely healthy. Neither cortical root and stem rot nor vascular wilt symptoms were present. Those plants inoculated with *F. solani* f. *pisi*, however, all showed typical brown to blackish lesions completely covering the two inches of underground hypocotyl of each plant.

Our conclusion is that the *Hypomyces* (=*Nectria*) reported by Buxton to be the perfect stage of *F. oxysporum* f. *pisi* is not the perfect stage of this fungus, nor the perfect stage of *F. solani* f. *pisi*. We suggest that this isolate is a homothallic, saprophytic fungus with an imperfect stage in *F. solani*. In our opinion, therefore, no perfect stage is yet known for any clone of *F. oxysporum*, nor for any clone of the pea root and stem rot form, *F. solani* f. *pisi*.

William C. Snyder
James V. Alexander

Department of Plant Pathology,
University of California,
Berkeley.

[1] Buxton, E. W., *Nature*, **184**, 1258 (1959).
[2] Gordon, W. L., *Nature*, **186**, 903 (1960).

Effect of 6-Methoxybenzoxazolinone on the Growth of *Xanthomonas stewartii* (Erw. Smith) Dowson and its Presence in Sweet Corn (*Zea mays* var. *saccharata* Bailey)

Previously[1] it was reported that 6-methoxybenzoxazolinone (MBOA) inhibited growth of fungi associated with root and stalk rot of field corn. This communication reports the inhibitory effect of MBOA on *Xanthomonas stewartii*, the causal organism of bacterial wilt (Stewart's disease), and the presence of this compound in the sweet corn plant.

The effect of various concentrations of MBOA in agar (beef extract 3 gm., agar 17 gm., distilled water 1,000 ml., adjusted to *p*H 6·0) on the growth of *X. stewartii* after 4 and 8 days is shown in Table 1. Inhibition of growth occurred at 0·15 mgm. per ml.,

Table 1. Growth of *Xanthomonas stewartii* on Agar (check) and on Agar containing MBOA

Concentration of MBOA (per ml. of agar) (mgm.)	Growth Days after inoculation 4	8
0 (check)	+ + +	+ + +
0·075	+ + +	+ + +
0·15	+	+ +
0·3	—	+
0·6	—	—

+ + +, maximum growth; —, no growth.

and the material was bactericidal at 0·6 mgm. per ml.

An ether extract of juice from the roots and stalks of two sweet-corn hybrids, prepared by the method reported earlier[2], significantly inhibited growth of *X. stewartii*. A chemical spot test for the determination of MBOA, in which diatized sulphanilic acid and sodium carbonate mixed with MBOA gives a characteristic reddish spot on filter paper, showed this compound to be present in the extract.

The fact that MBOA inhibits growth of *X. stewartii* and is present in the ether extract of sweet-corn plants suggests that this compound is a possible factor in resistance to bacterial wilt.

N. J. Whitney
C. G. Mortimore

Research Station,
Research Branch,
Canada Department of Agriculture,
Harrow, Ontario.

[1] Whitney, N. J., and Mortimore, C. G., *Nature*, **183**, 1320 (1959).
[2] Whitney, N. J., and Mortimore, C. G., *Nature*, **183**, 341 (1959).

Location of Manganese taken up in Short-term Absorption by Oat Roots

The oats (variety Sun II) used in experiments reported here were grown on waxed nylon mesh and supplied with Hoagland and Arnon's[1] culture solution modified by the omission of manganese chloride from the micronutrients. The roots were cut off below the netting when about 3–5 cm. long. They were washed with distilled water and immersed in a large volume of $M/1{,}000$ manganese sulphate solution for 2 hr.

At the end of this time the excised roots were washed with distilled water and stained by a technique based on that of Batalin[2]. The roots were treated as follows: 10 per cent aqueous potassium hydroxide solution for 5 min., removal of excess liquid by blotting, irrigation with 5 per cent *p*-anisidine solution for 5 min., and finally acidification with dilute sulphuric acid to reveal the presence of manganese by a purple coloration.

This procedure showed that most of the manganese was concentrated in the meristematic zone immediately behind the root cap (dark area in Fig. 1). As the dye is water-soluble such preparations are only temporary.

To exclude the possibility of an artefact caused by differential uptake of the dye, roots similarly prepared were analysed for manganese by the method of Cornfield and Pollard[3]. After absorption of manganese, and washing, the tips (about 2–3 mm.) were cut off, and the two portions sucked dry on a sintered glass filter, weighed and analysed. Manganese contents (as parts per million of fresh weight) are shown in Table 1.

Fig. 1

Table 1

	Manganese absorbed by: Complete excised roots	Tips and remainder separately
Tips (2–3 mm).	490 p.p.m.	260 p.p.m.
Remainder of roots	100 p.p.m.	130 p.p.m.

To test the possibility of translocation within the root to the meristematic region after more dispersed uptake the experiment was repeated, but root tips and the remainder of the roots were separated before being placed in two portions of $M/1{,}000$ manganese sulphate solution.

These figures are only approximate, since it is not possible, with the technique described, to separate efficiently the meristematic zone from the rest of the root.

Nevertheless the results show sufficiently clearly that: (*a*) short-term uptake of manganese occurs more rapidly in the meristematic region of the oat root; (*b*) translocation of manganese occurs within the root, since when the tips are separated, their uptake is lower, and that of the rest of the root higher, than when uptake occurs in the complete excised root.

It is a pleasure to record thanks to Prof. W. W. Fletcher and other members of the Botany Department of this College for providing microscopic and photographic facilities and other help, and to Dr. Ben-Zion Ginsberg (The Hebrew University, Jerusalem, now on a visit to the University of Edinburgh) for helpful discussion.

E. R. Page

West of Scotland Agricultural College,
New Building,
Auchincruive,
Ayr.

[1] Hoagland, D. R., and Arnon, D. I., Cal. Agric. Exp. Sta. Circ. 347 (revised) (1950).
[2] Batalin, A. Kh., *Pochvovedenie*, **9**, 124 (1957), quoted in *Soils and Fertilizers*, **21**, 63 (1958).
[3] Cornfield, A. H., and Pollard, A. G., *J. Sci. Food Agric.*, **1**, 107 (1950).

Relationship of Radiation, Leaf Area Index and Crop Growth-Rate

Shading experiments, such as those by Blackman and Templeman[1] on white clover, have shown the great reduction in crop growth-rate which occurs when light intensity is curtailed. A second factor influencing crop growth-rate is the leaf area index. There is evidence[2,3] that the rate of dry matter production by a crop or pasture will increase as the leaf area index increases, until a maximum value is attained; thereafter as the index increases further, the rate of dry matter production will decline. This is presumed to occur because the lowermost leaves become so heavily shaded at high leaf area index that their photosynthetic contribution is less than their respiration.

It is likely that these two inter-relationships, light and crop growth-rate, and leaf area index and crop growth-rate, may interact, and various workers,

especially Monsi *et al.*[4], have presented theoretical views on this subject.

In the course of competition studies at Adelaide, results have been secured on this inter-relationship between the level of radiation, the leaf area index and the rate of dry matter production. An experiment was conducted to study the influence of shading by grass on the growth of an associate clover when the roots of the two species were kept separate and there was competition only for light. Each species was grown in narrow, slot-like soil compartments; clover swards comprised a number of 'clover slots' placed together, while mixed swards were made up of alternating 'grass slots' and 'clover slots'. The percentage daylight at the surface of the clover canopy was determined by the use of a small selenium cell on a probe[5] and this percentage was applied to the values for total radiation recorded by a nearby Kipp solarimeter. In pure cultures of clover the surface light intensity was the full daylight; in the mixed cultures of grass and clover the light intensity at the surface of the clover was derived from the profile of the light intensity (based on readings at 2 cm. vertical intervals) and a measurement of the mean height of the upper clover leaves. Frequent harvests permitted calculation of the growth-rate of the clover during successive 14-day intervals. The experiments were done in the winter period June–August 1959; the weekly mean temperatures during these months showed unusually low variation (54·3° F. ± 2·7° F.).

The results of this work indicate that for any level of radiation there is an optimum leaf area index, at which crop growth-rate will be maximal, and that the value of the optimum index increases as radiation rises. These concepts are presented in Fig. 1 in which isopleths for crop growth-rate are drawn for varying levels of radiation and leaf area index. With a radiation of 50 gm.cal./cm.²/day the optimum leaf area index would be about 3·5, and the crop growth-rate low (0·07 gm./dm.²/day), whereas with a radiation of 150 gm.cal./cm.²/day the optimum leaf area index would be about 5, and the crop growth-rate relatively high (>0·1 gm./dm.²/day). The broken line indicates the rates of production when varying levels of radiation are associated with optimum values of leaf area index. To the left of this broken line, light interception is incomplete; to the right of the line, some of the lower leaves are below compensation point.

When shading of the clover by grass was severe, the entire clover community was below compensation point and negative values for growth-rate were recorded. The zero isopleth for crop growth-rate shows the level of radiation needed to keep a clover sward of any particular leaf area index at compensation point. It is suggested that extrapolation of this line to the lowest index values would follow the course shown by the dots—that is, it would turn sharply at the minimum index required to maintain plants alive. The part of the graph in which the isopleths are vertical and parallel is the zone in which an increase in radiation would give no further increase in growth-rate of a sward of any particular leaf area index.

The data are not sufficient to establish these relationships with precision but it suggested that they indicate the nature of the interactions in pasture swards and presumably also in crops and other plant communities.

W. R. Stern
C. M. Donald

Agronomy Department,
Waite Agricultural Research Institute,
University of Adelaide.

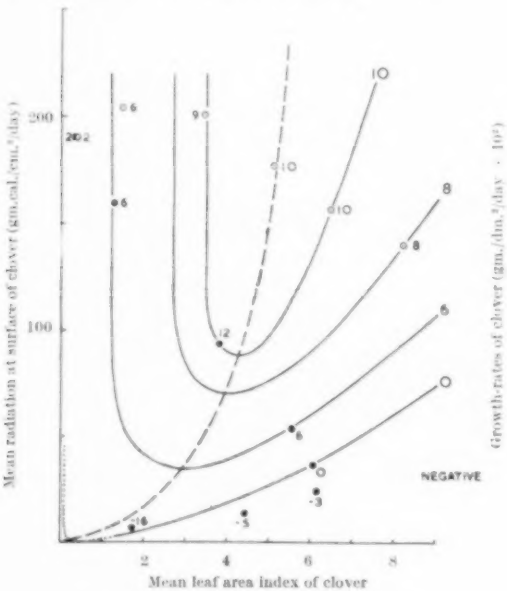


Fig. 1. ○, In pure stands; ●, in mixed stands

[1] Blackman, G. E., and Templeman, W. G., *Ann. Bot.*, **2** (N.S.), 257, 765 (1938).
[2] Watson, D. J., *Ann. Bot.*, **22**, 37 (1958).
[3] Davidson, J., and Donald, C. M., *Aust. J. Agric. Res.*, **9**, 53 (1958).
[4] Monsi, M., and Saeki, T., *Jap. J. Bot.*, **14**, 22 (1953). Kasanaga, H., and Monsi, M., *ibid.*, **14**, 304 (1954).
[5] Barrowman, J. N., Rep. *R259*, Dom. Phys. Lab., D.S.I.R., New Zealand (1956).

Possibility of Fixation of Atmospheric Nitrogen by the Rice Plant

A recent communication[1] by Chakraborty and Sen Gupta suggested that rice plants might be capable of fixing atmospheric nitrogen. We have made an attempt to confirm their result using the variety 'Lead 35' (a pure-line selection of material derived from British Guiana). No evidence of nitrogen-fixation has been obtained.

Chakraborty and Sen Gupta found that the maximum rate of nitrogen-fixation occurred in young plants—a gain of 50 per cent of the nitrogen content of 7-week-old plants being recorded after a further month in nitrogen-free medium. The percentage gain in older plants was substantially lower. For this reason our experiments have been carried out on young plants.

Rice plants were grown from seed in trays. Each tray of 30 seedlings contained 2 l. of nutrient medium of the following composition, changed at fortnightly intervals:

$MgSO_4.7H_2O$	0·35 gm./l.
$Ca(NO_3)_2$	0·92 ,,
KH_2PO_4	0·38 ,,
KNO_3	0·85 ,,
Ferric ethylenediamine tetraacetic acid	0·07 ,,
H_3BO_3	1·86 mgm./l.
$ZnSO_4.7H_2O$	0·29 ,,
$MnSO_4.4H_2O$	2·23 ,,
$(NH_4)_6Mo_7O_{24}$	0·035 ,,
*p*H	about 4·5

The whole apparatus was enclosed in a polythene cloche to prevent contamination of plants or medium by rain-water, dust and insects. Plants were grown for an initial period in complete medium, then removed and their fresh weights determined. After washing in three changes of distilled water, one batch was analysed by the micro-Kjeldahl method and the remainder were returned to the dishes to be grown for a further period, this time in a nitrogen-deficient medium similar to that used in the first period but with the omission or substitution of nitrogenous constituents. At the end of the second period, these plants were removed and analysed together with their dead leaves, which had been collected and preserved during the period of nitrogen starvation. The results were assessed by plotting fresh weight at the beginning of the period of nitrogen starvation against the Kjeldahl-nitrogen content before and after nitrogen starvation. Regression lines were then calculated for nitrogen content on fresh weight for each set of plants.

In the first experiment, 68 plants were grown, 44 analysed after the first three weeks and 24 after a further three-week period of nitrogen starvation. The equation for the regression line after the initial period was $y = 5{\cdot}49x - 0{\cdot}11$ ($r = 0{\cdot}976$), and after the period of nitrogen starvation $y = 6{\cdot}19x - 0{\cdot}52$ ($r = 0{\cdot}914$). Statistical comparison of these lines showed that there was no significant difference between their slopes and that no significant increase in the nitrogen content of the second batch had occurred. This was to be expected as marked deficiency symptoms had become apparent in the plants after they had been in the nitrogen-deficient medium for a week: leaves became chlorotic and eventually died from the tips. However, as heavier plants in this experiment had shown a tendency towards apparent gain in nitrogen content, a second experiment was carried out in which the initial period was increased to 4½ weeks. 52 plants were grown, of which 29 were analysed after the first period and 23 after nitrogen starvation. The results are shown in Fig. 1. The nitrogen contents of the starved plants were significantly higher than would be predicted from the first regression line. The apparent gain amounted to 17·7 per cent of the average initial nitrogen content per unit weight of fresh plant material. As the plants had again shown severe deficiency symptoms after a period of one week of nitrogen starvation, it was considered that an alternative explanation to that of nitrogen-fixation was likely. An attempt was made to determine the nitrate content of similar plants to discover whether nitrate reserves—not measurable by the ordinary micro-Kjeldahl method—were being used up during the period of nitrogen starvation and rendered amenable to determination by the Kjeldahl method, resulting in an increase in the measured nitrogen content of the plant.

Rice plants were grown as before for an initial period of 4 weeks. Analysis of 9 plants by the original micro-Kjeldahl method gave nitrogen contents comparable with previous results. Six plants from the same batch were dried at 105° C., extracted for 1 hr. with boiling water, and the extract distilled using magnesium oxide and Devarda's alloy for the determination of ammonium nitrogen. The content of nitrate nitrogen was found to be 17·5 per cent of the total nitrogen content of the plant. This figure is in agreement with the apparent gain in the previous experiment. We have found that the nitrate content of older plants is less: for example, 7-week-old plants contained 10·7 per cent of their nitrogen as nitrate. Reliance on ordinary Kjeldahl-nitrogen determinations would therefore result in an apparent decrease in 'fixation' in older plants. But we have also found that the nitrate content of plants grown in hydroponics is abnormally high when compared with rice plants growing under natural conditions: using the same analytical method, measurable quantities of nitrate nitrogen could not be detected in rice plants growing under field conditions, even when plants were sampled at daybreak from plots which had received heavy dressings of nitrogenous fertilizer.

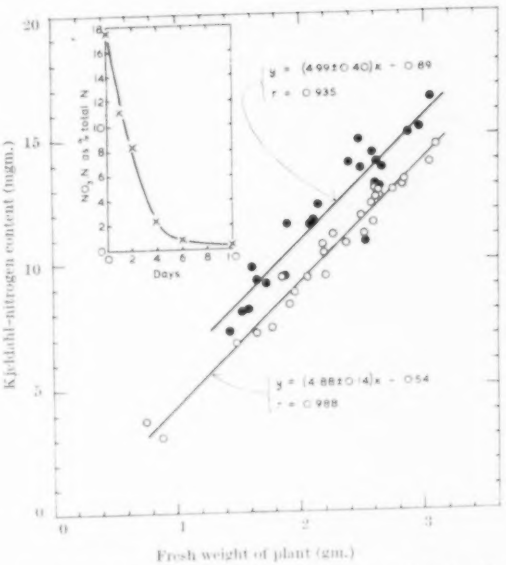


Fig. 1. Relationship between fresh weight of plants 4½ weeks old at the beginning of the period of nitrogen starvation and the Kjeldahl-nitrogen content before (○) and after (●) 3 weeks of nitrogen starvation. Inset: Depletion of nitrate in 4-week-old plants transferred to nitrogen-deficient medium

Fifteen of the 4-week-old plants were also transferred to the nitrogen-deficient medium from which they were afterwards removed at intervals and their nitrate content determined. The results are shown in the inset to Fig. 1. Severe symptoms of nitrogen deficiency were apparent after 7 days. At this stage the nitrate reserves of the plants were almost exhausted.

The results demonstrate that caution is necessary when applying the ordinary Kjeldahl methods to plants grown in hydroponics because of the unexpectedly high nitrate contents which may be found in such plants.

This communication is published with the permission of the Director of Agriculture, Sierra Leone.

M. G. R. Hart
E. H. Roberts

West African Rice Research Station,
Rokupr,
Sierra Leone.

[1] Chakraborty, S. P., and Sen Gupta, S. P., *Nature*, **184**, 2033 (1960).

ENTOMOLOGY

Enzymic Glucoside Synthesis in Locusts

Insects are known to convert foreign phenols to glucosides[1], and a few normally occurring glucosides have been identified in insects[2-4]. In other organisms the sugar for analogous glycoside synthesis comes from uridine diphosphate sugar derivatives and a similar process appears to function in insects the uridine diphosphate glucose (UDPG) of which provides the glucose for trehalose[5] and arbutin[6] formation. We have now investigated the distribution and extent of this mechanism and the specificity of its need for UDPG in the locust, *Schistocerca gregaria*.

The aglycone used as substrate was 4-methylumbelliferone, which forms fluorescent glycosides which may be hydrolysed by snail gastric enzyme or acid to the highly fluorescent phenol. Samples of reaction mixtures were chromatographed on No. 4 Whatman paper in 2-butanone/2 *N* ammonia (1 : 1, v/v) to separate the glucoside (R_F 0·6) from unchanged aglycone (R_F 0·8). The glucoside zone, located by examination under ultra-violet light, was eluted with *N* hydrochloric acid and estimated by measurement of its fluorescence at 410 mμ when activated at 320 mμ in an Aminco-Bowman spectrophotofluorimeter.

When separate tissues of fifth instar hoppers or adult locusts were examined, little conjugating activity was found in organs other than the fat body (Table 1). Measurements were also made of the conjugating capacity of whole locust carcasses after removal of the gut and Malpighian tubes. Locusts obtained on different occasions varied widely in their capacity but rates of formation of glucoside up to 250 μgm./hr./locust were found. For these experiments the carcasses were suspended in 5 ml. of saline[7] containing 0·5 mgm./ml. of methylumbelliferone and 0·1 ml. aliquots removed periodically for analysis. The concentration of glucoside increased linearly with time for at least 2 hr. and no difference in rate was observed with air or oxygen in the gaseous phase. The saline solution used contained 0·8 per cent (w/v) of glucose but omission of the sugar or replacement with equimolar amounts of trehalose or sucrose made no significant difference in the rate of glucoside synthesis.

Table 1. Distribution of glucoside-forming Activity in Locusts

Organ	Methylumbelliferone conjugated with glucose (μgm./hr./locust)
Washed foreguts	0·05
Washed gastric cecæ	0·06
Washed mid- and hind-guts	0·03
Mal ighian tubules	0
Fat bodies	2·0
Flight muscles	0
Hæmolymph	0

Each tube contained 0·1 mgm. 4-methylumbelliferone dissolved in 0·2 ml. grasshopper saline (ref. 7) at *p*H 7 and the tissues from 5th instar hoppers. Tubes were incubated at 37° for 1 hr. in air.

When fat bodies were homogenized for 5–10 sec. in a glass Potter homogenizer, the conjugating activity was reduced to very low levels but this could be restored to normal by addition of UDPG to the medium (Table 2).

Table 2. Effect of Homogenization and UDPG on Methyl Umbelliferone Glucoside Synthesis in Locust Fat Body

Experiment	Rate of glucoside formation (μgm./hr./locust)
1. Fat body suspension (3 fat bodies/ml.)	10·4
2. Fat body suspension after homogenizing	0·9
3. Fat body suspension after homogenizing and addition of UDPG 1 mgm./ml.	12·9

Fat bodies were suspended by shaking in saline and 1 ml. suspension used for experiment 1. The rest of the suspension was homogenized and 1 ml. of homogenate used for experiments 2 and 3. 4-Methylumbelliferone was added to each tube to give a concentration of 0·5 mgm./ml.

Homogenized fat bodies were centrifuged at 500–1,000 r.p.m. and the aqueous layer used as enzyme in determination of optimum substrate concentration and *p*H. The reaction showed a broad *p*H maximum at 7–8 and at this *p*H and with a methylumbelliferone concentration of 0·5 μgm./ml. the maximum rate of reaction was found with 1 mgm./ml. of UDPG.

Uridine diphosphate N-acetylglucosamine, which may be involved in chitin formation, was substituted for UDPG in similar experiments but no evidence was found of any glucosaminide formation. Similarly, UDPGA (uridine diphosphate glucuronic acid), which is used in analogous vertebrate detoxication reactions, gave no glucuronide when incubated with methylumbelliferone and intact or homogenized locust carcasses or fat bodies. In experiments where 0·1–1·0 equivalents of UDPGA were added to reaction mixtures containing the optimum concentration of UDPG, no inhibition of glucoside formation was observed.

This work was supported by grants from the Anti-Locust Research Centre.

J. N. Smith
Helen B. Turbert

Department of Biochemistry,
St. Mary's Hospital Medical School,
London, W.2.

[1] Smith, J. N., *Biol. Rev.*, **30**, 455 (1955).
[2] Pavan, M., in *Biochemistry of Insects*, edit. by Levenbrook, L., 36 (Pergamon Press, London, 1959).
[3] Kent, P. W., and Brunet, P. C. J., *Tetrahedron*, **7**, 252 (1959).
[4] Okubo, S., *Med. J. Osaka Univ.*, **9**, 327 (1958).
[5] Candy, D. J., and Kilby, B. A., *Nature*, **183**, 1594 (1959).
[6] Trivellani, J. C., *Arch. Biochem. Biophys.*, **89**, 149 (1960).
[7] Carlson, J. G., *Biol. Bull.*, **90**, 109 (1946).

Fate of Aldrin and Dieldrin in Locusts

Aldrin and dieldrin are widely used as insecticides, and dieldrin has been employed against locust hopper bands in the field. Aldrin is known to be epoxidized to dieldrin in insects[1,2], in vertebrates[3], in soils[4] and on plants[5]; but in many cases analytical difficulties have left the extent of the change not clear. The availability of aldrin and dieldrin labelled with chlorine-36 has now allowed us to examine quantitatively the metabolism and excretion of aldrin and dieldrin in *Schistocerca gregaria*.

Fifth instar hoppers were injected abdominally with an olive oil solution of the insecticides (2 μgm./5 μl.; about 100 c.p.m.) and kept at room temperature. Any insects surviving after seven days were added to the dead, which had been preserved under

Table 1. Excretion of Aldrin and Dieldrin by Locusts

Material used	Percentage of dose excreted	Percentage of chlorine-36 in bodies as: aldrin	dieldrin	water-soluble material	Percentage of chlorine-36 in excreta as: aldrin	dieldrin	water-soluble material*
Aldrin 1	3·3	62	39	0	44	52	5
2	21	67	36	0	57	41	3
3	—	—	42	—	—	—	—
Dieldrin 1	22	0	101	0	—	—	—
2	—	—	—	—	—	99	0
3	21	0	101	0	—	103	0

2 μgm. was injected in olive oil solution and surviving insects killed after 7 days.
* Not chloride.

ethanol. Excreta from each batch of locusts were collected at the end of seven days and similarly preserved under ethanol. Dosing of batches of locusts was repeated weekly until a total of 40,000 c.p.m. had been injected.

Excreta or bodies were homogenized in the Atomix blender with ethanol and filtered. The residue was then extracted in turn with acetone, 2 *N* ammonia and 0·1 *N* hydrochloric acid and the pooled filtrates concentrated *in vacuo* and counted as 'infinitely thin' layers on aluminium planchettes with a thin end-window counter. The extraction procedure was repeated until all the injected activity had been recovered.

The pasty residue left on concentration of the extracts was partitioned between water and benzene, and any water-soluble material removed and counted after concentration. Aliquots of the benzene solution were taken for dilution analysis with aldrin or dieldrin.

Aldrin was re-isolated from the mixture and crystallized to constant specific activity. Its radioactive purity was checked by conversion to the 2,4-dinitrobenzene sulphenyl derivative, m.p. 264°, with the same equivalent specific activity. Dieldrin was re-isolated, and its radioactive purity confirmed by conversion to the antimony chloride complex, which had the same equivalent specific activity.

This derivative was prepared by mixing equivalent amounts of dieldrin and antimony trichloride in hot *n*-hexane solution, from which the complex crystallized on cooling. It formed colourless needles from hexane, m.p. 122°, but decomposed in polar solvents. Found: Sb 19·6, Cl^- 17·5, $C_{12}H_8Cl_6O.SbCl_3$; required Sb 20·0, Cl^- 17·5 per cent. Antimony tribromide formed a similar complex, m.p. 131°. Found: Sb 16·4, Br^- 32·7, $C_{12}H_8Cl_6O.SbBr_3$; required Sb 16·4, Br^- 32·3. Endrin also formed similar complexes but aldrin and isodrin gave no derivative under these conditions.

Aldrin and dieldrin were only slowly excreted by locusts (Table 1) and the rate of oxidation of aldrin (Table 2) was considerably lower than has been reported for flies (about 0·1 μgm./hr./fly) under similar conditions[1]. A small amount of water-soluble material was found in excreta but could not be detected in the bodies in spite of the much larger amounts of radioactive material there. This was shown not to be chloride by dilution analysis and is being further investigated.

Dieldrin itself was not further metabolized and was slowly excreted unchanged.

Repeated sub-lethal doses of dieldrin, in contrast to di-nitro-*o*-cresol[6], should therefore act cumulatively in locusts as has been found with flies[7].

We are grateful to Prof. R. T. Williams for a gift of the radioactive insecticides used in this work.

Table 2. Oxidation of Aldrin to Dieldrin in Locusts

No. of locusts	Dose (μgm./locust)	Time after dosing (hr.)	Dieldrin formed (percentage of dose)	Rate of oxidation (μgm./dieldrin/locust/hr.)
12	1·8	44	22·7	0·011
12	1·8	60	39·1	0·012
12	1·8	72	42·0	0·011
29	1·8	(pooled dead)	42·2	—
7	0·9	93	54·0	0·005

5th instar locusts were injected with aldrin in olive oil and groups of 12 analysed for dieldrin at intervals. Insects dying at any time were pooled and analysed for dieldrin. No food was given and excreta were negligible.

The work was supported by grants from the Anti-Locust Research Centre.

A. J. Cohen
J. N. Smith

Department of Biochemistry,
St. Mary's Hospital Medical School,
London, W.2.

[1] Brooks, G. T., *Nature*, **186**, 96 (1960).
[2] Giannotti, O., Metcalf, R. L., and March, R. B., *Ann. Entomol. Soc. Amer.*, **49**, 588 (1956).
[3] Bann, J. M., DeCino, T. J., Earle, N. W., and Sun, Y. P., *J. Agric. Food Chem.*, **4**, 937 (1956).
[4] Gannon, N., and Bigger, J. H., *J. Econ. Entomol.*, **51**, 1 (1958).
[5] Gannon, N., and Decker, G. C., *J. Econ. Entomol.*, **51**, 3 (1958).
[6] McGuaig, R. D., and Sawyer, K. F., *Bull. Entomol. Res.*, **48**, 435 (1957).
[7] Hadaway, A. B., *Nature*, **178**, 149 (1956).

BACTERIOLOGY

Lipolytic Activity of Some Anaerobic Bacteria

The use of the water-soluble 'Tweens' for easy detection of lipolytic activity by micro-organisms has already been described by mo[1]. This technique has now been adapted to detect lipolytic activity of anaerobic bacteria. The best results were obtained by using the medium '*VF*' of Prévot with the addition of 'Tween 20', '40', '60', or '80' (polyoxyethylene sorbitan mono-laurate, mono-palmitate, mono-stearate and mono-oleate respectively) in a final concentration of 7×10^{-3} *M* plus 0·01 per cent (w/v) calcium chloride. After incubation at 37° C. the 'Tween' cultures were examined for the presence of opaque haloes, due to the formation of conspicuous precipitates of calcium laurate, palmitate, stearate or oleate around the zones of growth. The test was made either in tubes (8 mm. × 180 mm.) following the classical techniques for growing anaerobic bacteria,

Table 1. COMPARISON OF THE LIPOLYTIC ACTIVITY OF SOME ANAEROBIC BACTERIA AS SHOWN BY THE EIJKMAN AND SIERRA METHODS
The figures in brackets indicate the number of days after which a positive result could be observed. Cultures containing no lipolytic bacteria were observed during a month

Culture tested	Origin	Eijkman test (ox tallow)	Sierra test			
			'Tween 20'	'Tween 40'	'Tween 60'	'Tween 80'
Cl. histolyticum 1	*f*	–	–	–	–	–
Cl. histolyticum 2	*f*	–	–	–	–	–
Cl. multifermentans	*d*	–	–	–	–	–
Cl. fallax	*e*	–	–	–	–	–
Cl. butyricum CHH	*e, d*	–	–	–	–	–
Cl. butyricum	*e, d*	–	–	–	–	–
Cl. botulinum A, 3805	*c*	+ (4)	+ (4)	+ (4)	+ (4)	+ (4)
Cl. botulinum C, 3814	*c*	+ (4)	+ (8)	+ (8)	+ (8)	+ (8)
Cl. botulinum D, 33	*c*	+ (8)	+ (8)	+ (8)	+ (8)	+ (8)
Cl. oedematiens	*d*	+ (10)	+ (10)	+ (10)	+ (10)	+ (10)
Cl. botulinum A, 7948	*b*	+ (4)	+ (4)	+ (4)	+ (4)	–
Cl. botulinum E, 9564	*b*	+ (8)	+ (8)	+ (8)	+ (8)	–
Cl. botulinum B, 7949	*b*	+ (4)	–	+ (4)	+ (4)	–
Cl. botulinum D, 9633	*b*	+ (8)	–	+ (8)	+ (8)	–
Cl. perfringes A.	*d*	+ (8)	–	+ (8)	+ (8)	–
Cl. welchii A.	*a*	+ (10)	–	+ (10)	+ (10)	–
Cl. welchii B, 6121	*a*	+ (10)	–	+ (10)	+ (10)	–
Cl. botulinum C, 6060	*b*	+ (8)	+ (10)	–	–	–
Cl. agni C. var. *paludis*	*d*	+ (10)	–	+ (30)	–	–
Cl. agni D. var. *wildoni*	*d*	+ (10)	–	+ (10)	–	–
Cl. botulinum B, 213	*c*	–	+ (4)	+ (4)	+ (4)	+ (4)
Cl. sardelli	*c*	–	+ (10)	+ (10)	+ (10)	–
Staphylococcus anaerobius	*c*	–	+ (30)	+ (30)	+ (30)	–
Corynebacterium liquefaciens	*c*	–	+ (30)	+ (30)	+ (30)	–
Cl. welchii C, 4989	*a*	–	–	+ (30)	+ (10)	–
Cl. sporogenes	*d*	–	–	+ (10)	+ (10)	–
Cl. tetani Y.	*d*	–	–	+ (30)	+ (30)	–
Cl. tetani P	*d*	–	–	–	+ (30)	–

a, National Collection of Type Cultures, Central Public Health Laboratory, London; *b*, Central Hygiene Institute, Ankara; *c*, Pasteur Institute, Lille; *d*, Pasteur Institute, Paris; *e*, Wellcome Research Laboratories, Langley Court, Kent; *f*, Ibys Institute, Madrid.

or on plates in Brewer's jars. Simultaneously, lipolytic activity was tested by the Eijkman[2] method using the Prévot medium.

Table 1 shows that, of the twenty-eight strains tested, twenty-two had lipolytic activity. Although four of the lipolytic species did not exhibit any specificity, hydrolysing all four 'Tweens', eleven strains were able to hydrolyse only two or three of the four 'Tweens' tested. Four strains show a higher substrate specificity hydrolysing only one of the four 'Tweens'. Another striking feature of the 'Tween' test is its greater sensitivity than the Eijkman test. Seven strains which were non-lipolytic on the Eijkman plates were able to hydrolyse 'Tweens'.

These results may indicate that we are dealing with adaptive lipases which, however, cannot be detected with the Eijkman test (cf. ref. 1). Further investigations are being made to elucidate the specificity and mechanism of adaptation of these enzymes.

C. GONZALEZ
G. SIERRA

Department of Microbiology
and
Department of Biochemistry,
Jaime Ferràn Institute of Microbiology,
Madrid.

[1] Sierra, G., *Antonie van Leeuwenhoek*, **23**, 15 (1957).
[2] Eijkman, C., *Cbl. Bakt.*, Abt. I. Orig., **29**, 841 (1901).

Greater Susceptibility to *Mycobacterium johnei* of C.57 Black Mice, when compared with *CBA* and Swiss White Mice

RESEARCH on Johne's disease, a fatal enteritis of cattle and sheep due to infection with *Mycobacterium johnei*, has long been hampered by the lack of a suitable laboratory animal as an experimental host. In more recent years, Francis[1] and Lominski, Cameron and Roberts[2] have described the experimental infection of white mice; Ford[3], however, failed to demonstrate intestinal lesions in the latter species and I have obtained intestinal lesions in only a minority of inoculated Swiss white mice (unpublished work). It was decided to compare the susceptibility of two further strains of mice with that of the Swiss white strain.

Equal numbers of *C.57* black mice, *CBA* brindle mice (the foundation mice of both these stocks were obtained from the Medical Research Council Radiobiological Unit, Harwell, by courtesy of Dr. M. F. Lyon) and Swiss white mice (from stock maintained at this Station for several years) were inoculated intraperitoneally with 2 mgm. of moist *M. johnei* in suspension in saline; this strain of *M. johnei* was originally isolated from a case of the disease in a cow and was cultured on Taylor's medium[4].

Three months after infection, 15 mice of each strain were killed, and *M. johnei* infection of the intestines was detected, by histological methods, in two of the *C.57* mice and one of the Swiss white mice.

Six months after infection, six mice of each strain were killed; intestinal infection was detected in all six of the *C.57* mice and in three of the white mice, but not in the *CBA* mice.

Nine months after infection, six mice of each strain were killed. The small intestines of all six of the *C.57* mice were visibly enlarged, due to thickening of the mucosa; histological and smear examinations of the intestines confirmed the presence of *M. johnei* in the six *C.57* mice and in one of the six white mice, but in none of the *CBA* mice.

One year after infection, six mice of each strain were killed; the intestines of all six *C.57* mice, and two of the six white mice, were visibly thickened. *M. johnei* infection of the intestines was detected in the six *C.57* mice, in one white mouse and in one *CBA* mouse.

These results indicate that the three strains of mice differ in their susceptibility to intestinal infection with *M. johnei*. The susceptibility of the *C.57* black mice was markedly higher than that of the other strains.

A full report of this experiment will be published elsewhere. Further experiments are in progress to ascertain the suitability of the *C.57* black mouse as a laboratory animal for work on Johne's disease.

R. L. CHANDLER

Agricultural Research Council
Field Station,
Compton,
Berkshire.

[1] Francis, J., *J. Comp. Path.*, **53**, 140 (1943).
[2] Lominski, I., Cameron, J., and Roberts, G. B. S., *J. Path. Bact.*, **71**, 1, 211 (1956).
[3] Ford, E. J. H., *J. Path. Bact.*, **73**, 363 (1957).
[4] Taylor, A. W., *J. Path. Bact.*, **62**, 647 (1950).

The Host-Range of a *Streptomyces aureofaciens* Actinophage

A VIRULENT actinophage destructive to *S. aureofaciens* cultures and chlortetracycline (the trade mark of American Cyanamid Company for chlortetracycline is 'Aureomycin') fermentations had previously been reported[1]. Limited data regarding its host-range obtained at that time showed that it was a monovalent phage. Since other actinophages have been noted to be either polyvalent or monovalent[2], further tests have been made with the *S. aureofaciens* phage to establish more clearly the nature of its host-range.

Evidence is presented in this communication confirming that this phage is species-specific for *S. aureofaciens*. Tests for susceptibility to *S. aureofaciens* phage were made by spreading *Streptomyces* spore suspensions over the surface of corn-steep agar, resulting in confluent growth surfaces within 24–36 hr. When the spore suspensions had dried, the seeded surfaces were spotted with drops (0·01–0·02 ml.) of phage suspension using two concentrations in broth, 3×10^9 and 3×10^8 phage particles per ml. Controls consisted of broth and water drops spotted on the seeded surfaces. Observations for the presence of plaques were made after 1, 2, and 4–5 days. All tests were made at least in duplicate; in the case of a doubtful reaction, tests were repeated.

Representatives of forty diverse named species of *Streptomyces* other than *S. aureofaciens*, selected to encompass most sections and series of the genus as set up by Pridham *et al.*[3], showed no reaction to the phage. Tests were made with 3–5 strains each of *S. griseus*, *S. lavendulae*, *S. fradiae*, *S. antibioticus*, *S. rimosus*, *S. hygroscopicus*, *S. purpurascens*, *S. albogriseolus*, *S. tanashiensis* and *S. erythreus* and with one strain each of 30 additional species, use being made wherever possible of authentic strains from type culture collections.

Twenty-five soil isolates determined to be *S. aureofaciens* on the basis of morphological, cultural and physiological characteristics were also used in this work. Eighteen of these isolates were susceptible to the virulent *S. aureofaciens* phage, though some less than others, as indicated by reduced plating efficiency. The seven resistant isolates gave indications that their resistance was connected with the presence of homologous temperate phage(s) in their cultures. It is not definitely known whether these cultures are lysogenic or carry phage. Results with the *S. aureofaciens* group of isolates are recorded in Table 1.

Table 1. RESPONSE OF *Streptomyces aureofaciens* STRAINS TO *S. aureofaciens* PHAGE

Collection* designation	Phage reaction†	Collection* designation	Phage reaction†
A-1787	+ +	*AB*-357	−
A-2021	−	*AB*-708	+ + +
A-2380	+ +	*AC*-105	+ +
A-4342	+ + +	*AD*-417	±
A-5156	+ + +	*F*-2146	±
A-6496	+ + +	*T*-3452	±
A-7189	+ + +	*T*-3491	±
A-7300	±	NRRL 2209	+ + +
A-8202	−	NRRL *B*-1286	+ + +
A-9635	+ + +	NRRL *B*-1287	−
AA-689	+	NRRL *B*-1288	+ +
AA-772	+ +	ATCC 12416	+
AB-46	−		

* The designations of the first 20 strains are those of the Lederle Collection.
† Phage susceptibility (as indicated by plating efficiency): + + +, high; + +, intermediate; +, low; ±, very low (a few plaques observed); −, none (no plaques observed).

The possible utility of actinophage susceptibility as a criterion for species differentiation in the genus *Streptomyces* has been the subject of much discussion among investigators concerned with the taxonomy of this group. It seems to be generally agreed that polyvalent phages would be difficult to utilize because of their complex host relationships, but that species-specific, monovalent phages would have definite applicability, in conjunction with other taxonomic features characterizing *Streptomyces* species[2,4,5]. Susceptibility of newly isolated *Streptomyces* cultures to such a species-specific phage would reinforce other results on their close relationship to the phages' host species. Lack of susceptibility, however, would not exclude an isolate from being allied with the host species, as species susceptible to phages are generally known to comprise strains resistant to the same phages.

In the light of this evidence that the subject *S. aureofaciens* actinophage is species-specific, it was extremely interesting from a taxonomic point of view to extend this investigation to include three controversial organisms, *S. viridifaciens*[6], *S. psammoticus* (*S. feofaciens*)[7] and *S. sayamaensis*[8]. Although described as separate new species by those who isolated them, these organisms have morphological, cultural and physiological properties which raise serious doubts as to their distinction from *S. aureofaciens*. The results obtained, all three proving to be susceptible to the virulent, monovalent *S. aureofaciens* phage, add support to the contention that these three species should be reduced to synonomy with *S. aureofaciens*.

R. WEINDLING
H. D. TRESNER
E. J. BACKUS

Chemical Production Section and Biochemical Research Section,
Lederle Laboratories,
American Cyanamid Company,
Pearl River,
New York.

[1] Weindling, R., and Kapros, Ch., *Bact. Proc., Soc. Am. Bact.*, 48 (1951).
[2] Welsch, M., *Microbiol.*, **28**, 451 (1959). (A.I.B.S. translation from Russian *Microbiologiya*, **28**, 421 (1959).)
[3] Pridham, I. G., *et al.*, *App. Microbiol.*, **6**, 52 (1958).
[4] Kutzner, H. J., and Waksman, S. A., *Bact. Proc. Soc. Am. Bact.*, 30 (1959).
[5] Gilmour, C. M., and Ingalshe, C., *J. Bact.*, **78**, 193 (1959).
[6] Gourevitch, A., and Lein, J., U.S. Pat. 2,712,517 (1955).
[7] Bellenghi, M., West German Pat. Appl. I.21111 (1956).
[8] Japanese Pat. 255818 (1959).

GENETICS

Morphological Separation of Cytological Races in *Ranunculus ficaria* L.

The presence of axillary tubercles ('bulbils') in the various races of *Ranunculus ficaria* L. *sensu lato* is still a matter of some debate. So far as British material is concerned, previous workers have shown that all tubercle-bearing plants investigated cytologically have been tetraploid, with $2n = 32$, while non-tubercle-bearing plants have been diploid ($2n = 16$). Marsden-Jones[1] proposed separating the tubercle-bearing plants as var. *bulbifera*, as opposed to typical non-tubercle-bearing plants which were later described by Clapham[2] as var. *fertilis*. The two races were later raised to sub-specific rank by Lawalrée[3].

Other differences between the two races given by Marsden-Jones were: number and relative width of the petals, range in stamen and carpel number, proportion of viable pollen and viable seed set. This range of variation in stamens and carpels is such, however, that they do not form useful characters for taxonomic separation.

In Table 1 details are given of the floral characters and cytological status of a selection of the populations studied in north Wales and Cheshire. Measurements were made of samples of 100 plants in each population. The following points may be noted.

Petal range. Although the mean petal number has usually been found to differ between diploid and tetraploid populations, the position of the mean is not correlated overall with the level of ploidy (for example, Nos. 5906, 5915 in Table 1); similarly, although there appears to be a difference in petal range this is not constant and in any event the overlap between the two makes it an unreliable character.

Petal type. Two types of petal are commonly recognized: broad and overlapping in the diploid and narrow, not overlapping, in the tetraploid. In practice we have found an intermediate to occur so frequently that it became necessary to recognize a third type. This intermediate type has been found in both races. Apart from this, the broad-type petal has been found in tetraploids and the narrow in diploids, contrary to what is normally stated (Nos. 5906, 6001). Consequently, no reliance can be placed on petal type as a diagnostic character.

Table 1

Reference No.	Character: Axillary tubercles + or −	No. of stamens	No. of carpels	No. of petals	Petal type	Chromosome number n =	Habitat
5903	−	27–35	25–44	(7–)8(–11)	1	8	Hedgerow
5904	−	19–37	22–31	8(–10)	2	8	Hedgerow
5906	−	50–60	45–50	9–11	3	8	Woodland
5907	−	30	30	.	1	16	Hedgerow
5908	−	24–43	26–45	8(–9)	2	8	Roadside
5909	−	23–30	14–37	(7–)8(–9)	1	8	Roadside
5910	−	30	30	8	1	8	Woodland
5912	+	35	50	.	3	16	Woodland, riverside
5915	+	20	12–19	7–8	2	16	Riverside
5916	+	17–40	13–30	8(–10)	2	8	Woodland
5917	+	23–30	23–30	7–8	3	16	Woodland
6001	+	22–32	7–26	8–10	1	16	Woodland
6002	−	23–29	13–23	8	3	8	Woodland

+ or − is presence or absence of axillary tubercles. Petal type: 1, broad, overlapping; 2, intermediate; 3, narrow, not overlapping.

Presence or absence of bulbils has always been considered a distinguishing character for the two races. However, it has not always been realized that the tubercles are only produced towards the end of the flowering season and this in itself has caused some confusion: presence of tubercles is a positive character while absence may imply true absence or simply young material which will later develop tubercles. Almost equal reliance has been placed on the suggested floral differences for taxonomic distinction, notably petal number and degree of overlap, particularly in the absence of tubercles. These differences have been widely accepted and never, as far as we are aware, disputed.

Field and laboratory studies on local populations in north Wales and Cheshire during the past few years have pointed to the unreliability of these floral characters as a means of distinguishing the two cytological races. In some populations the characters given by Marsden-Jones hold good but it is not uncommon to find them completely reversed in other populations. This is specially true of the petal characters. Thus while it is possible to separate populations in the same locality into morphologically different types, agreeing with the diploid and tetraploid races suggested by Marsden-Jones, actual cytological investigation has shown that some apparent tetraploids have proved to be diploids and vice versa.

The conclusions that may be drawn from the above data are that in the absence of axillary tubercles, in young material, petal type is not a reliable cytological marker since it is not constantly correlated with level of ploidy. Furthermore, it is not entirely certain that the association of tubercles with the tetraploid is always constant, although it would generally appear to hold good. It may be possible to separate the diploids and tetraploids by other characters associated with the frequency and position of the flower buds in the inflorescence, but in any event it is quite clear that the recognition of the different cytological races by morphological characters is by no means so simple as is usually believed, if indeed it is consistently possible at all. It should be emphasized that these studies have been made on populations from only a small part of the range of the species and they are being extended to other areas. Details of the present and other investigations will be published separately.

V. H. Heywood

Department of Botany,

S. Walker

Sub-Department of Genetics,
University of Liverpool.

[1] Marsden-Jones, E. M., *J. Linn. Soc.* (*Lond.*) (*Bot.*), **50**, 40 (1935).
[2] Clapham, A. R., in Clapham, A. R., Tutin, T. G., and Warburg, E. F., "Flora of the British Isles", 101 (Cambridge, 1952).
[3] Lawalrée, A., "Flore Générale de Belgique", **2** (1), 59 (1955).

FORTHCOMING EVENTS

(Meetings marked with an asterisk • are open to the public)

Monday, February 20

UNIVERSITY OF LONDON (at the Institute of Education, Malet Street, London, W.C.1), at 5.15 p.m.—Prof. J. W. Tibble: "The Training College and Higher Education."•

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Prof. T. A. Bennet-Clark, F.R.S.: "Experimental Design in Pesticide Research".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. H. B. G. Robinson (Kansas City): "Some Effects of Ageing on the Oral Structures".•

INSTITUTION OF MECHANICAL ENGINEERS, NUCLEAR ENERGY GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "The Influence of Availability of Enrichment upon Reactor Type and Design".

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATE AND STUDENT SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. K. M. Jones: "Testing High Voltage Interconnected Systems with particular reference to the Kariba Scheme".

Tuesday, February 21

UNIVERSITY OF LONDON (at the Imperial College of Science and Technology, Prince Consort Road, London, S.W.7), at 1.30 p.m.—Mr. J. Christopher Jones: "Human Factors in Engineering Design".•

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT, SUPPLY AND UTILIZATION SECTIONS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Scientific Papers.

ROYAL SOCIETY OF MEDICINE, PATHOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 5.30 p.m.—Meeting on "Electron Microscopy".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. R. W. Riddell: "Fungi Causing and Complicating Human Disease".• (Twelfth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation.)

UNIVERSITY OF LONDON (in the Gustave Tuck Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. K. H Spring: "Introductory Survey".• (First of five lectures on "Generation of Electricity without the use of Rotating Machinery".)

INSTITUTE OF INFORMATION SCIENTISTS (at the Caxton Hall, Caxton Street, London, S.W.1), at 6.15 p.m.—Dr. J. G. Malloch: "The Work of the British Commonwealth Scientific Organization".•

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. D. C. Libby: "Magnetic Resonance Studies on High Polymers".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. N. P. Inglis: "Newer Metallic Materials of Construction".

Wednesday, February 22

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. J. F. Loutit: "Radiation and Leukæmia".•

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY, COLOUR GROUP (at Battersea College of Technology, Battersea Park Road, London, S.W.11), at 3 p.m.—Dr. V. S. Griffiths: "Colour and Chemistry".

INSTITUTION OF ELECTRICAL ENGINEERS, ELECTRONICS AND COMMUNICATIONS SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. J. M. Meggitt: "Coding Theory and its Applications".

BRITISH INSTITUTION OF RADIO ENGINEERS, MEDICAL ELECTRONICS GROUP (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Discussion on "Transistorized Medical and Biological Electronic Equipment".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Prof. P. M. S. Blackett, F.R.S.: "Controlled Fusion Reactions" (Thomas Hawksley Lecture).

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—The Right Hon. Lord Nathan, P.C.: "Geography and the Business World To-day".

SOCIETY OF CHEMICAL INDUSTRY, FOOD AND MICROBIOLOGY GROUPS (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Meeting on "The Microbiology of the Deep Frozen Foods". Dr. H. Rachel White: "Some Aspects of the Microbiology of Frozen Peas": Dr. B. J. Wagg and Miss M. Boothroyd: "The Effect of Processing and Freezing on the Bacteria in Frozen Meat Products".

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (in Room 425, Birkbeck College, Malet Street, London, W.C.1), at 8 p.m.—Section Annual General Meeting. Dr. W. A. Belson: "Television and the Family".

Thursday, February 23

CHEMICAL SOCIETY (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, London, S.W.7), at 10.30 a.m.—Symposium on "Terpene Chemistry".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. W. B. G. Horton: "Gods as Guests—Ritual Drama in a West African Tribe".•

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Gordon Sutherland, F.R.S.: "Some Recent Developments at the National Physical Laboratory".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. H. J. Koch: "Metabolism and Variation in the Blind Cave Fish *Caecobarbus geertsi*"; Dr. V. C. Robertson: "The Jebel Marra, Western Sudan".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. W. J. Whelen: "Recent Advances in the Chemistry and Biochemistry of Glycogen and Starch".• (Further lecture on March 2.)

UNIVERSITY OF LONDON (at Guy's Hospital Medical School, St. Thomas's Street, London, S.E.1), at 5.30 p.m.—Dr. Morton I. Grossman (Veterans Administration Centre, Los Angeles): "Regulation of Pancreatic Secretion".•

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. G. B. Koelle (University of Pennsylvania): "Acetylcholinesterase in Synaptic and Neuroeffector Transmission".•

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. A. G. Everson Pearse: "Enzyme Histochemistry and its Biochemical Alignments".• (Thirteenth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation.)

INSTITUTE OF METALS, METAL PHYSICS COMMITTEE (at the Royal Institution, Albemarle Street, London, W.1), at 6.30 p.m.—Prof. W. Hume-Rothery, F.R.S.: "The Theory of the Alloys of Copper".

OIL AND COLOUR CHEMISTS' ASSOCIATION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. N. R. Barucha: "Pigments in Corrosion Prevention".

Friday, February 24

BRITISH PSYCHOLOGICAL SOCIETY, OCCUPATIONAL PSYCHOLOGY SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. J. D. Handyside: "Satisfactions and Aspirations" (Chairman's Address).

INSTITUTE OF RURAL LIFE AT HOME AND OVERSEAS (at Friends International Centre, 32 Tavistock Square, London, W.C.1), at 1.15 p.m.—Commissioner H. A. Lord: "The Needs of Rural People in Korea".•

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 4 p.m.—Prof. H. Harris: "The Inborn Errors of Metabolism".•

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "Radio Studies of the Aurora". Chairman: Mr. J. A. Ratcliffe, F.R.S. Speakers: Dr. J. W. Dungey, Dr. S. Evans, Dr. C. D. Watkins and Mr. W. R. Piggott.•

SOCIETY OF ANALYTICAL CHEMISTRY, MICROCHEMISTRY GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.45 p.m.—Annual General Meeting. 7 p.m.—Mr. F. Holmes: Retiring Chairman's Address.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. Martin Ryle, F.R.S.: "Radio Astronomy and Cosmology".

Saturday, February 25

BIOCHEMICAL SOCIETY (in the Physics Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 10.10 a.m.—403rd Meeting.

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. A. Robinson: "Bird Watching in the Medway Valley".•

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

CHEMICAL RESEARCH ASSISTANT/TECHNICIAN (preferably with experience of steroid chemistry) to work with a team investigating aspects of chemical endocrinology in relation to human biology and genetics—Dr. J. M. Tanner, Institute of Child Health, Great Ormond Street, London, W.C.1 (February 23).

ASSISTANT LECTURER or LECTURER IN PHYSICS—The Registrar, The University, Sheffield (February 25).

ASSISTANT LECTURER or LECTURER (with a special interest in physiology) IN BOTANY—The Secretary, The University, Exeter (February 25).

JUNIOR LECTURER (preferably with interests in the fields of either (*a*) soils and climate or (*b*) regional geography) IN GEOGRAPHY—The Registrar, Trinity College, Dublin, Republic of Ireland (February 27).

RESEARCH STUDENT (with experience in one of the following fields: medicine, chemistry, biochemistry, or pharmacology) IN PHARMACOLOGY, for work on naturally occurring neuro-muscular blocking agents—The Registrar, Trinity College, Dublin, Republic of Ireland (February 27).

ASSISTANT LECTURER (with a good honours degree with special interests in mineralogy) IN GEOLOGY—The Registrar, King's College (University of London), Strand, London, W.C.2 (February 28).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF MATHEMATICS, Makerere College, The University College of East

Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 28).

University Librarian—The Secretary and Registrar, The University, Southampton (February 28).

Plant Physiologist (with a good honours degree in botany and research experience) for investigations of effects of temperature, oxygen and carbon dioxide on the respiration of fruit—The Director, Ditton Laboratory, A.R.C., Larkfield, Maidstone, Kent (March 1).

Research Assistant to operate and maintain the electron microscope and ancillary equipment in the Metal Physics Section of the Cavendish Laboratory—The Secretary of the Department of Physics, Cavendish Laboratory, The University, Free School Lane, Cambridge (March 1).

Education Psychologist, Grade I (man or woman)—The Director of Education, Shire Hall, Durham (March 3).

Lecturer (with a good honours degree, teaching experience up to degree level, and research experience) in Zoology at the Nigerian College of Arts, Science and Technology, Zaria Branch—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (March 3).

Lecturer (preferably with a special interest in microwaves and microwave devices, both vacuum and solid state) in Applied Physics—The Secretary, The University, 38 North Bailey, Durham (March 4).

Research Assistant (British nationality) in the Wheatstone Laboratory for research on cathodoluminescence, scintillation properties, etc., of certain elementary crystals—Prof. F. C. Champion, Department of Physics, King's College (University of London), Strand, W.C.2 (March 5).

Librarian at the University College (Fourah Bay College), Sierra Leone—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 6).

Helminthologist, Scientific Assistant (with a degree and experience in helminthology) to prepare abstracts and assist in editorial work on *Helminthological Abstracts*—The Acting Director, Commonwealth Bureau of Helminthology, The White House, 103 St. Peter's Street, St. Albans, Herts (March 11).

Imperial Chemical Industries Research Fellows in Biochemistry, Chemistry, Chemical Oceanography, Engineering and Physics—The Registrar, The University, Southampton (March 11).

Lecturer in Physical and/or Inorganic Chemistry in St. Salvator's College, St. Andrews—Joint Clerk to the University Court, The University, St. Andrews (March 11).

Official Fellow and Lecturer in Physiology; and a Demonstrator in Physiology—The Warden, New College, Oxford (March 11).

University Demonstrator in Physiology—The Administrator, Department of Physiology, The University, South Parks Road, Oxford (March 11).

Assistant Lecturer or Lecturer in the Department of Pure Mathematics—The Registrar, University College of Wales, Aberystwyth (March 13).

Lecturer or Assistant Lecturer in Psychology—The Registrar (Room 22, O.R.B.), The University, Reading (March 18).

Lecturer in Geography at Rhodes University, Port Elizabeth, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, March 20).

Reader in Inorganic Chemistry at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 20).

Senior Lecturer in Horticulture at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, March 25).

Senior Lecturer in Physics at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, April 28).

Ferranti Fellow (with at least two years research experience) in Computing, to do original work in any field connected with computation or other application of digital computers, with access to a Ferranti Mercury—The Director, University Computing Laboratory, 9 South Parks Road, Oxford (July 31).

Demonstrator in Agricultural Botany; and a Demonstrator in Agricultural Zoology at the School of Agriculture, Sutton Bonington—The Registrar, The University, Nottingham.

Junior Research Fellow in Chemistry—The College Secretary, Balliol College, Oxford.

Lecturer (preferably with industrial experience such as in nuclear fuel processing) in Chemical Engineering for the Nuclear Technology Group—G. R. Hall, Department of Chemical Engineering and Chemical Technology, Imperial College of Science and Technology, London, S.W.7.

Lecturer (with a good medical qualification and some laboratory experience) in the Department of Bacteriology and Immunology—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

Technician (female) in the Physics Laboratory, for work concerned chiefly with diagnosis and treatment using radioactive isotopes—The Hospital Secretary, Dudley Road Hospital, Birmingham, 18.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The Association of Teachers in Technical Institutions. Comments on the Crowther Report. Pp. 15. (London: Association of Teachers in Technical Institutions, 1960.) [1711

The Chest and Heart Association. Smoking: a Message from an M.O.H. Pp. 8. (London: Chest and Heart Association, 1960.) [1711

Annual Report and Accounts of the British Broadcasting Corporation, 1959–60. Pp. 175+8 plates. (Cmnd. 1174.) (London: H.M. Stationery Office, 1960.) 9*s*. net. [1711

Symposia of the Zoological Society of London. No. 3: Sensory Specialization in Response to Environment Demands—Proceedings of a Symposium held at the Zoological Society of London, Regent's Park, London, on 4th March, 1960. Pp. iv+83+3 plates. (London: Zoological Society of London, 1960.) 17*s*. 6*d*. [1711

Forestry Commission. Bulletin No. 32: Afforestation of Upland Heaths. By J. W. L. Zehetmayr. Pp. v+145+34 plates. (London: H.M. Stationery Office, 1960.) 17*s*. 6*d*. net. [1711

Titles of Dissertations approved for the Ph.D., M.Sc., and M.Litt. Degrees in the University of Cambridge during the Academical Year 1959–60. Pp. iii+20. (Cambridge: Board of Research Studies, The University, 1960.) [1711

University of Leeds. Annual Report, 1959–60 (Draft of principal sections). Pp. ii+37. (Leeds: The University, 1960.) [1711

National Physical Laboratory. Effects of Variation in the Ambient Air on the Calibration and Use of Ionization Dosemeters. By Dr. G. P. Barnard, Dr. G. H. Aston and A. R. S. Marsh. Pp. 31. (London: H.M. Stationery Office, 1960.) 2*s*. 6*d*. net. [1811

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 1025, Vol. 253 (17 November, 1960): The Classical Field Theory of Matter and Electricity. 1: An Approach from First Principles. 2: The Electromagnetic Theory of Particles. By S. R. Milner. Pp. 185–226. 13*s*. 6*d*. No. 1026, Vol. 253 (19 November, 1960): Quadratic Diophantine Equations. By G. L. Watson. Pp. 227–254. 9*s*. No. 1027, Vol. 253 (17 November, 1960): On Adsorption at the Oil/Water Interface and the Calculation of Electrical Potentials in the Aqueous Surface Phase. 2: The Effects of Ionic Size. By D. A. Haydon and F. H. Taylor. Pp. 255–275. 6*s*. 6*d*. (London: The Royal Society, 1960.) [1811

Other Countries

United States Department of the Interior: Geological Survey. Bulletin 1045-F: Core Logs from Five Test Holes near Kramer, California. By William K. Benda, R. C. Erd, and Ward C. Smith. Pp. iv+319–393+plates 11 and 12. Bulletin 1085-C: Botanical Prospecting for Uranium in the Circle Cliffs Area, Garfield County, Utah. By Frank J. Kleinhampl and Carl Koteff. Pp. iii+85–104+plates 7 and 8. Bulletin 1104-A: Erosion and Related Phenomena at Paricutin in 1957. By Kenneth Segerstrom. Pp. iii+18+1 plate. 50 cents. Bulletin 1111-A: Devonian Rugose Corals from Northern Maine. By William A. Oliver, Jr. Pp. iii+23+plates 1–5. Bulletin 1116-A: Geophysical Abstracts, No. 180, January-March, 1960. By James W. Clarke, Dorothy B. Vitaliano, Virginia S. Neuschel, and others. Pp. iii+128. 40 cents. (Washington, D.C.: Government Printing Office, 1960.) [1711

United States Department of the Interior: Geological Survey. Professional Paper 260-X: Smaller Foraminifera from Eniwetok Drill Holes. By Ruth Todd and Doris Low. Pp. iv+799–861+plates 255–264. Professional Paper 260-Y: Drilling Operations on Eniwetok Atoll. By Harry S. Ladd and Seymour O. Schlanger. Pp. iv+863–903+plates 265 and 266. Professional Paper 282-D: Flow Resistance in Sinuous or Irregular Channels. By Luna B. Leopold, Ralph A. Bagnold, Mr. Gordon Wolman and Lucien M. Brish, Jr. Pp. iv+111–134+plates 3 and 4. Professional Paper 282-E: Some Aspects of the Shape of River Meanders. By Ralph A. Bagnold. Pp. iv+135–144. 20 cents. Professional Paper 315-C: Stratigraphic Distribution of some Pennsylvanian Fusulinidae from Brown and Coleman Counties, Texas. By Donald A. Myers. Pp. iii+37–53+plates 15–24. 45 cents. Professional Paper 316-D: Gravity Survey of the Western Mojave Desert, California. By Don R. Mabey. Pp. iii+51–73+plates 10–12. (Washington, D.C.: Government Printing Office, 1960.) [1711

United States Department of the Interior: Geological Survey. Professional Paper 334-F: Ammonites of Early Cretaceous Age (Valanginian and Hauterivian) from the Pacific Coast States. By Ralph W. Imlay. Pp. iii+167–228+plates 24–43. 1.25 dollars. Professional Paper 340: Trepostomatous Bryozoa of the Hamilton Group of New York State. By Richard S. Boardman. Pp. iii+87+plates 1–22. 1.25 dollars. Professional Paper 352-B: The Shape of Alluvial Channels in Relation to Sediment Type. Pp. iii+17–30+plate 5. Professional Paper 354-D: Early Cretaceous (Albian) Ammonites from the Chitina Valley and Talkeetna Mountains, Alaska. By Ralph W. Imlay. Pp. iii+87–114+plates 11–19. 50 cents. Professional Paper 354-G: Deposition of Uranium in Salt-Lan Basins. By Kenneth G. Bell. Pp. iii+161–169. 20 cents. Professional Paper 400-B: Short Papers in the Geological Sciences—Geological Survey Research 1960. Pp. viii+515. 4.25 dollars. (Washington, D.C.: Government Printing Office, 1960.) [1711

The Weizmann Institute of Science. Serial Holdings of the Weizmann Institute of Science (complete until May, 1960). Pp. iii+62. (Rehovoth, Israel: Weizmann Institute of Science, 1960.) [1711

Queensland. Fifteenth Annual Report of the Council of the Queensland Institute of Medical Research, year ended 30th June, 1960. Pp. 26. (Brisbane: Queensland Institute of Medical Research, 1960.) [1711

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £8 8*s*.–, payable in advance, postage paid to any part of the world.

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

For Qualified

SCIENTISTS, ENGINEERS, ARCHITECTS AND SURVEYORS

THE TECHNICAL AND SCIENTIFIC REGISTER

provides a National Employment and Advisory Service. All enquiries are dealt with in confidence by professionally qualified staff.

A leaflet, giving details of the Service, will be sent on request.

Write for information or appointment to

THE TECHNICAL AND SCIENTIFIC REGISTER, Dept. K.10, Almack House, 26 King Street, London, S.W.1.

Telephone: WHI 6200 (Ext. 328)

Issued by the Ministry of Labour

Plan Ahead

by effecting now "the young man's policy" which gives to a man under 35 immediate life assurance cover at low cost and the valuable right to effect within ten years further assurances even though his health has become impaired.

The Equitable has no shareholders and pays no commission for the introduction of business; unusually attractive terms can, therefore, be offered.

Write today for details to

The Equitable Life Assurance Society

(Founded 1762)

Head Office: **19 Coleman Street, London, E.C.2**

Please send me, without obligation, details of the young man's policy.

Name .....

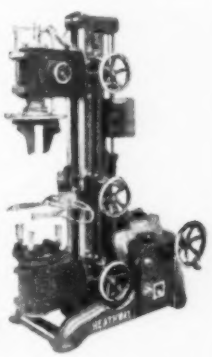
Address .....

Heathway

Glass Working Lathes

are known throughout the world

- 5 types available
- May we send you leaflets?



The new universal model in its vertical position

HEATHWAY MACHINERY CO. LTD.

UXBRIDGE ROAD, HILLINGDON, MIDDLESEX

TELEPHONE: UXBRIDGE 6345

Agents in the U.S.A. and France

Richoux Co. Inc., 1133 Broadway, New York 10, N.Y.

Ets. L. Richoux, 22 Cité Trévise, Paris 9e

APPOINTMENTS VACANT

McGILL UNIVERSITY

BRACE EXPERIMENT STATION, BARBADOS, W.I.

Applications are invited for the post of DEPUTY DIRECTOR, BRACE BEQUEST, to supervise all activities at the Brace Experiment Station, Barbados. The appointment has the academic status of senior lecturer in a Commonwealth University and will be on contract for three years subject to extension. The salary range will be from £1,750 (sterling) per annum, depending upon qualifications, plus insurance scheme and assistance towards accommodation. Free passages will be provided for the appointee and family at the beginning and termination of contract.

The Brace Bequest, with headquarters in Montreal, has recently been established to further research and development in the fields of engineering and experimental agriculture for eventual application in underdeveloped arid countries. Initially the Deputy Director will be required to supervise technical staff and postgraduate students developing and testing equipment for the conversion of salt water to fresh water and for water pumping, operated by either solar or wind energy. Desirable qualifications would include professional training in mechanical or chemical engineering, experience in applying the principles of thermodynamics, heat and mass transfer, hydraulics and aerodynamics in the development of engineering equipment and a broad outlook towards the objectives of the Brace Bequest. Academic experience in the guidance of postgraduate students would also be an advantage.

Detailed applications, naming three referees, and accompanied by a recent photograph should be submitted before April 1, 1961, to The Dean, Faculty of Engineering, McGill University, Montreal, Canada, from whom further particulars may be obtained.

UNIVERSITY OF LEEDS

DEPARTMENT OF PHILOSOPHY

Applications are invited for appointment, in the Department of Philosophy, to a Leverhulme Research Fellowship in the History and Philosophy of Science. The Fellowship, which is renewable, will be tenable for one year in the first instance, and will be of a value up to £1,350.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained) not later than March 17, 1961.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(UNIVERSITY OF READING)

Experimental Officer required in Nutrition Department for biochemical research on problems of protein and amino acid metabolism. Candidates should be graduates, or hold A.R.I.C., H.N.C., or an equivalent qualification and should have had experience in the use of the techniques of paper and column chromatography. Salary scale, minimum age 27, £1,057 to £1,336; pension scheme.

Apply, naming two referees, to Secretary, N.I.R.D., Shinfield, Reading. Quote ref. 61/6.

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

RESEARCH STAFF— MINERAGRAPHIC INVESTIGATIONS

(2 POSITIONS)

The Organization's **Mineragraphic Investigations Section**, located in grounds of Melbourne University, Victoria, invites applications for two research positions. The Section is concerned with studies of the mineral resources of Australia to provide information on the mineral composition and origin of ores.

Applicants, who should be honours graduates with some years' research experience, preferably in opaque minerals, are required to participate in the mineralogical and petrological research on ores and ore occurrences with emphasis on the opaque minerals. Experience in the application of spectrographic and X-ray techniques to mineral identification an advantage.

SALARY: dependent on qualifications and experience within the ranges: £A.1,510 to £A.2,265 per annum.

Salary for women will be £A.180 per annum less than corresponding rates for men.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the scale within which the original appointment is made.

Fares paid. Further details may be obtained on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting Appointment No. 450/13), should be addressed by April 8, 1961.

United Kingdom Atomic Energy Authority

Require

ANALYSTS

Post A

The work associated with this post is varied and involves an analytical service to research projects on the less common metals and their alloys and compounds.

Post B

To assist in the assessment of chemical compatibility of a wide range of materials. The work will include development of various techniques for assessment by accelerated testing and the establishment of suitable criteria. Some experience of physico-chemical procedures applied to investigation of physical or chemical changes would be of advantage.

The Laboratories at Aldermaston are of modern design and are well equipped with modern physical instruments.

Applicants should have a pass degree or H.N.C., together with appropriate experience in a related field of work, e.g., corrosion, degradation of organic materials, or practice of analysis.

Appointments will be made in the Experimental Officer or Assistant Experimental Officer grade with salary ranges as follows:

EXPERIMENTAL OFFICER	£1,165 to £1,430.
ASSISTANT EXPERIMENTAL OFFICER	£640 (at age 21) to £860 (at age 26 or over) to £1,055 per annum.

Superannuation Scheme. A house or substantial assistance with house purchase will become available to married officers living beyond daily travelling distance.

Please write for application forms to the Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks, quoting reference 2873/34.

KING'S COLLEGE HOSPITAL

DENMARK HILL, S.E.5

Applications are invited for an appointment as Senior Physicist. The successful candidate will be expected to act as deputy to the Principal Physicist and to take responsibility in radiation physics and isotope work. Some experience in hospital physics is necessary. There are also opportunities for research in a wide range of problems in the application of physics to medicine. Salary according to Whitley Council scales for the Senior Grade, £1,300 to £1,750 a year including London weighting.

Applications, together with the names of two referees, should be sent to the undersigned.

J. D. BANKS,
House Governor.

THE POLYTECHNIC

309 REGENT STREET, W.1

DEPARTMENT OF CHEMISTRY AND BIOLOGY

Applications are invited for a post as Grade B teacher for Inorganic and Physical Chemistry. Some previous industrial and/or teaching experience, and an interest in research, would be an advantage. The salary scale for a graduate rises to £1,240 per annum plus London allowance of £38 or £51 and additional allowances for training and good honours, where appropriate.

A form of application, which should be returned by not later than February 25, 1961, may be obtained from the undersigned.

J. E. RICHARDSON,
Director of Education.

G.E.C.

APPLIED
ELECTRONICS
LABORATORIES
THE AIRPORT - PORTSMOUTH

Are engaged in the development of a wide range of electronic and electro-mechanical projects. We have an immediate requirement for

QUALIFIED
ENGINEERS

particularly if they have experience in the design and development of transistorized circuitry.

This is a progressive establishment employing young men with advanced ideas.

Increasing commitments necessitate expansion of staff at all levels and promotion prospects are excellent.

Our senior technical staff will be pleased to have informal discussions, at week-ends if desired.

Please write in confidence to the Personnel Officer.

UNIVERSITY COLLEGE OF SWANSEA

Applications are invited from suitably qualified candidates for the following posts: Pure Mathematics, A Research Fellowship in the Theory of Probability and/or Mathematical Statistics. Physics, two Assistant Lectureships or Lectureships (one post will be Superintendent of Laboratories). Chemistry, an Assistant Lectureship or a Lectureship. Geology, an Assistant Lectureship or a Lectureship, with particular interest in Mesozoic stratigraphy and palaeontology. A Research Demonstratorship. Geography, two Assistant Lectureships. Zoology, an Assistant Lectureship and a Lectureship.

Salary Scales: Lectureships, £1,050 by £50 to £1,400 by £75 to £1,850 per annum. Assistant Lectureships, £800 by £50 to £950 per annum. Research Demonstratorships, £650 to £700 per annum. Research Fellowships, within the range £800 to £1,100 per annum. F.S.S.U. benefits and family allowances.

Further particulars can be obtained from the Registrar, University College, Singleton Park, Swansea, by whom applications (six copies) must be received not later than Saturday, March 11, 1961.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING AND CHEMICAL TECHNOLOGY

Applications invited for Lecturer in Chemical Engineering for Nuclear Technology Group. Industrial experience, such as in nuclear fuel processing, an advantage. Scale £1,050 by £50 to £1,400 by £75 to £1,550 (bar) by £75 to £1,850 per annum, plus £60 London allowance and family allowances.

Applications to G. R. Hall, Imperial College, S.W.7.

UNIVERSITY OF QUEENSLAND

SENIOR LECTURER IN GEOLOGY (GEOCHEMIST)

Applications are invited for the above-mentioned post, which is a responsible teaching position with excellent opportunity for geochemical and petrological research in a large University. Applicants should have a Science degree and research experience to Ph.D. or comparable level; present dominant interest should be in Geochemistry (theoretical and economic). Some experience in rock and mineral analysis and ability to do fundamental research is expected. An interest in isotope geology and at least some experience in mass spectrometry is desirable. Some interest in X-ray spectrography or other special techniques could be an advantage. Salary £A.2,520 by £A.70 to £A.2,870 per annum. The successful applicant will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff.

Further particulars may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on March 31, 1961.

NATIONAL VEGETABLE RESEARCH Station, Wellesbourne, Warwick, has a vacancy in its Statistics Section. The successful candidate will be required to do advisory work on the design and analysis of experiments, and research work on biometrical problems. Access to electronic computer. Appointment either as Scientific Officer (qualification: good honours degree in mathematics, Scale, £717 to £1,222), or as Assistant Experimental Officer (qualification: pass degree or equivalent, Scale, £543 to £983). In either class, starting salary determined by age and experience and there are prospects of promotion to higher grades. Contributory superannuation scheme.—Applications, with names and addresses of three referees, to Secretary, by March 6, 1961.

ROYAL NAVAL SCIENTIFIC SERVICE

ADMIRALTY require SENIOR SCIENTIFIC OFFICERS/SCIENTIFIC OFFICERS at

A. UNDERWATER WEAPONS ESTABLISHMENT, PORTLAND, DORSET (Ref. C69/1A)

(1) Mechanical Engineer. Specialized in thermodynamics with experience in internal combustion engine research and/or rocket propulsion field. Minimum five years' experience in either expected. Some experience in appropriate instrumentation essential with design study work on components of rocket systems or other propulsion gear. Turbine design experience advantageous.

(2) Mechanical Engineer with bias for one or more of: (i) hydraulically operated mechanisms, including servo-control; (ii) mechanics of machines (theory and practice); (iii) hydro- (or aero-) dynamics of fairly elementary character.

(3) Hydrodynamicist (or aeronautical engineer), with some years' experience for work on torpedo dynamics.

(4) Mechanical Engineers (servo-mechanisms, gyro design and develop). Electrical Engineers (Electronics/Design). Mathematicians (Operational research and theoretical physics). Physicist (acoustics).

B. GOVERNMENT COMMUNICATIONS H.Q., CHELTENHAM (Ref. A43/1A)

Physicists (Telecommunications). Mathematicians. Electrical Engineers (Electronics/Radar; Telecommunications and Radio).

C. NAVAL CONSTRUCTION RESEARCH ESTABLISHMENT, DUNFERMLINE (Ref. C70/1A)

Structural and Mechanical Engineers, Mathematical Physicists and Mathematicians, for teams engaged on research problems of structural strength, effects of conventional and nuclear weapons and development of new structural materials. Excellent opportunities and good prospects for promotion.

D. ADMIRALTY COMPASS OBSERVATORY, SLOUGH (Ref. D47/1A)

Electrical or Mechanical Engineers or Physicists interested in gyro-techniques, servo-mechanisms or electronics.

Qualifications for all posts first- or second-class honours degree or equivalent in appropriate subject. Must normally be natural born British subjects of natural born British parents. Senior Scientific Officers must have had minimum three years' postgraduate experience and be not less than 26 years of age.

Salaries: (A.) Senior Scientific Officer, £1,302 to £1,604; Scientific Officer, £717 to £1,186. (B, C, D.) Senior Scientific Officer, £1,342 to £1,654; Scientific Officer, £738 to £1,222.

Appointments unestablished (with F.S.S.U. benefits) but opportunities for those between 21 and 32 to compete for established posts.

Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate reference and post.

THE DURHAM COLLEGES in the University of Durham

Applications are invited for the post of Lecturer in Physics from October 1, 1961.

Applications (three copies), together with the names of three referees, should be sent not later than March 25, 1961, to the Secretary, 38 North Bailey, Durham, from whom further particulars may be obtained.

McGILL UNIVERSITY

DEPARTMENT OF CHEMISTRY

Post-doctoral appointments are available for studies in:

(1) Chemistry of the Upper Atmosphere (atom reactions, chemiluminescence, mass spectrometry).

(2) Nuclear and Radiochemistry.

(3) Studies in physico-chemical aspects of Immunochemistry.

(4) Physical Chemistry of Interfaces.

(5) Organic Chemistry of Wood and Cellulose.

Salary: $5,300 per year.

Applicants should submit official documents attesting to academic qualifications and at least two supporting letters to the Chairman, Department of Chemistry, McGill University, Montreal, Quebec, Canada.

BAKELITE LIMITED

TYSELEY, BIRMINGHAM

require a

GRADUATE PHYSICIST

with some industrial experience to take charge of an experimental laboratory in the Physics and Physical Chemistry Section of their Research and Development Department.

This is a good opportunity to develop a responsible position and a progressive career in applied physics with a leading manufacturer of plastics materials.

A booklet describing the work of the Department may be had on request and applications should be addressed to the

RESEARCH & DEVELOPMENT MANAGER

BAKELITE LIMITED

Redfern Road, Tyseley

BIRMINGHAM 11

COURTAULDS

ANALYSTS

COURTAULDS has the following vacancies for analysts in its research organization at Coventry.

1. **Microanalyst** (reference D.8a/3)

An analyst who has specialized in microanalysis; for work involving the development and application of microanalytical techniques in the high polymer field.

A sound knowledge of general chemistry is essential, but practical experience of microanalysis is regarded as of greater importance than high academic qualifications.

The successful candidate will work with a small group whose main function is the development of new analytical techniques applicable to the solution of specific problems which arise in the course of the work of one of the principal research laboratories of the Company.

2. **Development Analyst** (reference D.8b/3)

An analyst to carry out general analytical development work in the Chemical Engineering Section and particularly, to work in collaboration with a team of physicists engaged in the development of instruments for automatic continuous analysis, applicable to process control in pilot and full scale chemical plant.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds Limited, 16 St. Martin's-le-Grand, London, E.C.1, quoting the appropriate reference number.

ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY GLASGOW

SENIOR LECTURESHIP IN HEALTH PHYSICS

Applications are invited for this post with which will be associated the Headship of the Radiation Control Laboratory. Duties include organization of postgraduate courses on nature and control of radiation hazards, inauguration of research and supervision of radiation safety throughout the College.

Candidates should be physicists with experience in university teaching and interested in the problems of radiation safety.

Salary scale £1,975 by £75 to £2,275, with F.S.S.U. and family allowances.

Form of application from the Secretary, George Street, C.1.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Applications are invited for a Lectureship in Pure Geochemistry from October 1, 1961. Salary range £1,050 to £1,850 per annum plus £60 London allowance, F.S.S.U. membership and family allowances. Candidates should have geochemical qualifications and be familiar with one or more of the following techniques: optical or X-ray spectrography, silicate or radioactive analysis.

Apply to Professor D. Williams, Department of Geology, Imperial College of Science and Technology, London, S.W.7.

UNIVERSITY COLLEGE OF WALES
ABERYSTWYTH

Applications are invited for the post of Assistant Lecturer or Lecturer in the Department of Pure Mathematics to take up duties on October 1, 1961. Salary scales: Lecturer, £1,050 to £1,850; Assistant Lecturer, £800 to £950, plus Superannuation benefits and children's allowances.

Further particulars can be obtained from the Registrar, to whom applications should be sent, together with the names of two persons to whom reference may be made, not later than March 13, 1961.

UNIVERSITY OF TORONTO
DEPARTMENT OF MATHEMATICS

Applications are invited for vacancies in the Applied Mathematics Section of the Department. Preference will be given to applicants with experience in quantum mechanics and fluid dynamics. Rank and salary will depend on qualifications and experience. Superannuation and removal allowances are available.

Applications should be sent to Professor D. B. DeLury, Chairman, Department of Mathematics, University of Toronto, Toronto 5, Canada.

OLDCHURCH HOSPITAL ROMFORD, ESSEX
(709 Beds)
RADIOTHERAPY DEPARTMENT

Senior Technician or Technician required for the above Department. Duties include Physics Workshop, Isotope Laboratory, Radium and Mould Room work. Instrument or Physics Workshop experience essential. Salary £570 to £710 per annum; senior grade, £710 to £905 per annum would be applicable to suitably qualified person.

Applications, quoting Ref. 17/39, giving full details, including age and experience, together with names of two referees and/or copy of testimonials to the Group Secretary, Romford H.M.C., Oldchurch Road, Romford.

NEW COLLEGE, OXFORD
UNIVERSITY DEMONSTRATOR IN PHYSIOLOGY

The University proposes to appoint with effect from October 1, 1961, a University Demonstrator in Physiology. The post may be held in conjunction with a college fellowship. Stipend in the scale £1,050 to £2,025 per annum or, if medically qualified, £1,350 to £2,175; children's allowance of £50 per annum for each child.

Three copies of applications, with the names of two referees, by March 11, 1961, to the Administrator, Department of Physiology, South Parks Road, Oxford, from whom further details can be obtained.

UNIVERSITY OF OXFORD
OFFICIAL FELLOWSHIP IN PHYSIOLOGY

New College intends, if a suitable candidate presents himself, to elect to an Official Fellowship and Lectureship in Physiology from October 1, 1961. The post may be held in conjunction with a University post. A Demonstratorship in Physiology is advertised from the same date.

Further details may be obtained from the Warden, New College. Closing date for applications, March 11, 1961.

SOUTH OF SCOTLAND ELECTRICITY BOARD

Applications are invited for the undernoted superannuable appointments at HUNTERSTON NUCLEAR GENERATING STATION:

(a) STATION CHEMIST (Ref. G4/61)

The successful applicant will supervise the conventional and radiochemical station laboratories and be responsible for the testing and treatment of waters, gases and oils, radioassay of effluents and plant arisings and measurement of activity levels in district survey samples. Candidates should have had experience in a modern generating station and possess a university degree or equivalent qualification. The successful applicant will be expected to undergo special training with the U.K.A.E.A.

Salary—N.J.B.—Class M, Grade 6—£1,650/£1,830 per annum.

(b) ASSISTANT STATION CHEMIST (Ref. G5/61)

The successful applicant will be responsible to the Station Chemist for the work of the district survey laboratory, measuring the levels of total activity and of specific isotopes in district survey samples. He may also be expected to participate in routine station chemical analyses. Candidates should preferably have had some experience of low level activity measurements and background counting techniques and possess a Higher National Certificate, or equivalent qualification.

Salary—N.J.B.—Class M, Grade 9—£1,350/£1,500 per annum.

Forms of application may be obtained from the Secretary, South of Scotland Electricity Board, Inverlair Avenue, Glasgow, S.4, and returned quoting appropriate reference, not later than February 24, 1961.

ROAD RESEARCH LABORATORY (Traffic and Safety Division), Langley, Bucks, requires Senior Scientific Officers/Scientific Officers to carry out Theoretical and Experimental Research on Traffic Flow and Road Safety, including psychological aspects, physics of friction and impact problems, relationship between vehicle design and injuries sustained in road accidents, theoretical problems on traffic and application of electronic computer to these problems. Qualifications: First- or second-class honours degree or equivalent, in appropriate subject for Scientific Officer, with adequate postgraduate research experience and minimum age 26 for Senior Scientific Officer. Salary ranges: Scientific Officer, £710 to £1,175; Senior Scientific Officer, £1,290 to £1,593 (according to experience). Normal prospects of promotion in mid-thirties to Principal Scientific Officer, £1,650 to £2,325, with possibilities of higher posts. Opportunities for early establishment with superannuation whilst under age 31. Laboratory expected to move to new accommodation at Crowthorne, near Bracknell, Berkshire in 1963.—Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 286/OA.

THE BRITISH GLASS INDUSTRY RESEARCH Association requires a Section Leader to take charge of the Glass Technology Section. Applicants should have had sufficient experience of commercial glass making to enable them confidently to assist members who require help. This help might be on specific problems in the factory or by designing suitable programmes of laboratory investigations. The successful applicant will also be required to lead the research projects now being undertaken; these include work on the refining of glass, a study of gases in glass and investigations on the mechanism of heat transfer in glass forming operations. These projects are being developed by suitably qualified staff but the Section Leader must have a sufficiently wide scientific background to enable him to evaluate their work and direct it along channels most useful to the membership of the Association. Salary according to age and experience with F.S.S.U. superannuation.—Applications, quoting names of two referees, should reach the Director, The British Glass Industry Research Association, Northumberland Road, Sheffield 10, not later than March 4, 1961.

PHARMACOLOGIST REQUIRED TO WORK in London for the first two years in an academic department and thereafter in a newly created Research Laboratory in London. Non-contributory Pension and Life Assurance Scheme and excellent salary; scope for promotion.—Write, giving full details of age, qualifications, experience and salary required to the Managing Director, Biorex Laboratories Limited, 47/51 Exmouth Market, London, E.C.1.

ROLLS-ROYCE

AERO ENGINE DIVISION

RESEARCH GROUP

PHYSICISTS · CHEMISTS METALLURGISTS & ENGINEERS

are required for a programme of expansion of challenging work on materials research following upon recent advances made by our Solid State Physics Group.

We are concerned with (a) the application of results of our fundamental programme to the development of new structural materials, and (b) an extension of the programme of basic work.

Qualifications required for senior posts are a good honours degree, preferably some relevant postgraduate experience, initiative and a flair for original thinking. There are also some junior posts vacant for which at least an H.N.C. would be necessary.

Working conditions are excellent and every encouragement is given for publication of original work, and salaries will be commensurate with the high standards set.

Applications should be addressed to:
OH/Mbd., ROLLS-ROYCE LIMITED, OLD HALL, LITTLEOVER, DERBY.

ENGLISH ELECTRIC VALVE CO. LTD.

Chelmsford, Essex

A Physicist or Mathematician is required for research on electron optical systems.

Applicants should possess a first- or second-class honours degree in physics or mathematics, and be preferably within age range 22 to 30.

Salary will take into account age and any previous relevant experience.

Apply to Department G.P.S., English Electric House, Strand, London, W.C.2, quoting reference N1595P.

DALHOUSIE UNIVERSITY

HALIFAX, NOVA SCOTIA, CANADA

As part of an expansion programme applications are invited for the following positions:

Assistant Professor in Microanatomy to teach medical and science students and conduct research in embryology. Preference will be given to candidates with a science degree in zoology or medical qualification.

Assistant Professor in Gross Anatomy primarily to teach gross anatomy, with opportunities to participate in research and in other responsibilities of the department. Modern facilities for research available. The salary for an Assistant Professor with medical qualifications will be not less than $8,500, depending upon qualification.

Inquiries for both appointments should be addressed to Professor R. L. de C. H. Saunders at the above address.

BIOCHEMIST WITH POSTGRADUATE EXperience required to assist in research project on bacterial polysaccharides. Some knowledge of bacteriological techniques desirable but not essential. The appointment is subsidized by a grant from the Medical Research Council, is for one year in the first instance, and is renewable. Salary according to experience and qualifications.—Applications to the Director, Central Enteric Reference Laboratory, Central Public Health Laboratory, Colindale Avenue, London, N.W.9.

A LABORATORY TECHNICIAN WITH biochemical experience is required to work in the Department of Chemical Pathology on research connected with muscle diseases. Salary up to £700 per annum, according to qualifications and experience.—Applications should be made in writing to the Secretary, Institute of Neurology, National Hospital, Queen Square, W.C.1.

ENGLISH ELECTRIC

VALVE COMPANY LIMITED

Microwave Research and Development

The Company has considerable effort engaged on research and development into very low noise microwave tubes.

Physicists and engineers are required to assist in this programme and whilst we would prefer graduates with experience in this field of activity we would be pleased to hear from graduates with good honours degrees backed up with industrial experience in light electrical or electronic companies.

Employment would be at the Company's Works in Chelmsford, Essex.

Inquiries should be addressed to: Group Personnel Services, English Electric House, Strand, London, W.C.2, quoting reference N1506M.

The European Organization for Nuclear Research (C.E.R.N.)

GENEVA, SWITZERLAND

HEALTH-PHYSICS

The 25 GeV. Proton Synchrotron and the 600 MeV. Synchro-Cyclotron are now working at full capacity. The successful operation of these machines requires an expansion of the Health Physics Section to deal with new and interesting problems as well as with more conventional surveys. Applications are invited from

PHYSICISTS and TECHNICIANS

experienced and interested in Radiation Protection, Research and Development work in High Energy Dosimetry, and collaboration with other research physicists of many nationalities.

Good salaries according to qualifications and experience, plus certain allowances. Excellent social security and leave conditions.

Application Forms from:

Personnel Officer, C.E.R.N., Geneva 23

CULHAM LABORATORY

for fusion and plasma physics research now being built at Culham, nr. Abingdon, Berks,

will require a

SCIENTIFIC OFFICER

to lead a small experimental team engaged in the investigation of phenomena associated with the interaction of photons and elementary particles with surfaces of various materials.

The work will include the interpretation of results from experiments involving the use of mass spectrometric and spectroscopic gas analysis, and the design of ultra high vacuum apparatus and electron, ion, and plasma sources.

The successful candidate will be appointed to the Controlled Thermonuclear Reactions Division at A.E.R.E., Harwell, and will subsequently be transferred with his work to the Culham Laboratory.

Applicants should have a first- or good second-class Honours Degree in Physics, Physical Chemistry, or Physical Metallurgy.

Salary £790 to £1,310 per annum; for three years' postgraduate experience starting salary £1,010.

Housing and contributory superannuation schemes.

Send a postcard for details to:

The Personnel Officer (CAP/40/09/34), Culham Laboratory, A.E.R.E., Harwell, Berks.

CITY OF LIVERPOOL EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY

Principal: S. A. J. Parsons, B.Sc.(Econ.) M.I.Mech.E., M.I.Prod.E., M.B.I.M.

Applications are invited for the following appointments. Duties to commence September 1, 1961.

(1) Two Lecturers in Chemistry. Applicants should be willing to undertake research and have had previous postgraduate experience in either Organic or Inorganic Chemistry.

(2) Lecturer in Mathematics. Applicants should have an honours degree and preferably have had teaching and/or industrial experience. The capacity to develop postgraduate work and research is desirable. This is a new post due to the expansion of the mathematical section of the department, particularly in connection with Numerical Analysis and Statistics.

(3) Assistant, Grade "B," in Botany and Zoology to G.C.E. Advanced Level. A knowledge of Horticulture would be helpful.

Salaries in accordance with the Burnham Technical Report: Lecturers, £1,370 by £35 to £1,550 per annum. (The commencing salary will be assessed according to previous industrial, professional and appropriate teaching experience.) Assistant, Grade "B," £700 by £27 10s. to £1,150 per annum. (Additional graduate and training allowances, where applicable, will be paid and the commencing salary will be assessed according to previous industrial, professional and teaching experience.)

Application forms (returnable by March 3, 1961) and further particulars from H. S. Magnay, M.A., Director of Education, 14 Sir Thomas Street, Liverpool, 1.

THOMAS ALKER,
Town Clerk and Clerk to the Local Education Authority (J.6643).

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE, 1

DEPARTMENT OF PHYSICS

The Council of King's College invite applications for appointment to a Lectureship in Physics. The commencing salary will be determined at a suitable point on the Lecturers' scale (£1,050 to £1,850), according to age, qualifications and experience of the successful applicant. F.S.S.U. and child allowance.

Further particulars may be obtained from the Registrar and Secretary of King's College, to whom applications, together with the names and addresses of three persons to whom reference may be made, should be addressed so as to reach him not later than March 10, 1961.

TECHNICIAN (FEMALE) AGE 25 to 32 years wanted. Duties flexible would include responsibility for sterilization of surgical equipment and other biological or chemical work. "A" level in chemistry and biology, S.R.N. or I.M.L.T. training or equivalent an advantage.—Apply in own handwriting, giving age, education and experience, to Administrator, University Laboratory of Physiology, Oxford.

RESEARCH ASSISTANTSHIP OPEN September, 1961, on solid state physical chemistry of mucopolysaccharides. Research can be used for thesis for Ph.D. degree. Stipend $3,000 per year plus remittance of travel expense up to $200.—Candidates having Master degree or equivalent training apply to Dr. Bettelheim, Adelphi College, Garden City, New York, U.S.A.

UNIVERSITY OF ALBERTA

DEPARTMENT OF CHEMISTRY

TEACHING ASSISTANTSHIPS

$2,200 to $2,700 for eight months are open to qualified students proceeding to advanced degrees. Nine hours per week of laboratory instruction required. Active research programmes in analytical, inorganic, organic, physical and theoretical chemistry. Travel allowance.

Apply to: Professor Harry E. Gunning, Head, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada.

CHEMICAL RESEARCH ASSISTANT/Technician, preferably with experience of steroid chemistry, to work with team investigating aspects of chemical endocrinology in relation to human biology and genetics.—Apply, giving two referees, Dr. J. M. Tanner, Institute of Child Health, Great Ormond Street, W.C.1. Closing date February 23.

McGILL UNIVERSITY

POSTGRADUATE ASSISTANTSHIPS IN CHEMISTRY

Applications are invited from persons qualified to pursue M.Sc. and Ph.D. work in Chemistry for Teaching and Research Assistantships. Stipends are dependent on the number of hours per week given to teaching work. The maximum is 12 hours per week, for which a Teaching Fellow will receive $1,800 to $2,000 for the months of October to May inclusive. Stipends may be supplemented by a summer grant of $800 for the months of June to September inclusive, provided that the applicant carries on work leading to the degree during this period.

Research opportunities are available in Analytical Chemistry, Inorganic Chemistry, Radiochemistry, Physical Chemistry, Colloid Chemistry, Immunochemistry, Organic Chemistry, and the Chemistry of Cellulose and Lignin.

For further information please write to:

The Chairman,
Department of Chemistry,
McGill University,
Montreal, Quebec, Canada.

CENTRAL ELECTRICITY GENERATING BOARD

ASSISTANT HEALTH PHYSICIST

Applications are invited from candidates who wish to be considered for appointment as the Assistant Health Physicist at the **Berkeley Nuclear Laboratories.** The duties of the post will include the organization and supervision of the Health Physics measurement programme. The successful applicant who will deputise for the Health Physicist in his absence, will be encouraged to do original work related to this programme and will be in a position to gain sufficient experience to qualify as a Health Physicist.

Candidates should have a degree or equivalent qualification and some experience in radiation measurement would be an advantage. Applicants should preferably be under 26 years of age and must be keenly interested in health physics work.

The successful applicant will be offered an appointment at a salary of up to £1,325 per annum, depending on experience, ability and qualifications.

Applications, stating age, qualifications, experience, present position and salary, to the Appointments Officer, 24/30 Holborn, London, E.C.1, by March 3. Envelopes should be marked "Confidential Ref. N./63."

BRITISH COLUMBIA RESEARCH COUNCIL

BIOLOGICAL ENGINEER

The British Columbia Research Council invites applications for an appointment as a Biological Engineer. There are also vacancies in Applied Biology and Bacteriology. Background training in Chemistry or Chemical Engineering with some experience in biochemistry and bacteriology would be desirable for the position in Biological Engineering. The work will include the study of water quality, the design of systems for the treatment of industrial wastes, and the preparation of technical reports. The British Columbia Research Council is a non-profit applied research organization established at the University of British Columbia. The salary range for these positions is $6,500 to $8,500 with the same pension and other benefits in effect at the University. Those interested should write for an illustrated brochure describing the activities and research facilities of the Council.

Applicants should submit full information regarding training and experience to Dr. P. C. Trussell, Head, Applied Biology Division, B.C. Research Council, Vancouver 8, Canada.

THE PATENT OFFICE

offers an interesting, well paid job with good prospects to suitably qualified men and women in congenial working conditions.

interest — You will be dealing with inventions from the whole world in your chosen subject. By its very nature the work will inevitably maintain your knowledge of science and technology completely up to date and will give you inside knowledge of new manufactures well ahead of the public at large.

salary — The training salary for the first two years is £793 and £824. On satisfactory completion the scale is £941–£1,719 by regular increments, but there is a jump in the scale to £1,324 five years after entry, or only four or even three in cases of special merit. Approved postgraduate experience fetches a higher starting salary. One promotion only, of which prospects are excellent, raises your maximum to £2,715. Reasonable proportion of still higher posts up to £3,865 all filled exclusively by promotions from entry grade.

qualifications — Age 21–36 and first- or second-class honours degree in physics, chemistry, engineering or mathematics, or an equivalent such as A.R.I.C., A.Inst.P., or corporate membership of I.C.E., I.Mech.E., or I.E.E., or first- or second-class honours Diploma of Technology.

conditions — Location, London, five-day week. Annual leave 4½ rising to 6 weeks. Posts are permanent and pensionable (non-contributory).

Write or telephone for further information, or for a visit to the Patent Office to see the work, entirely without obligation. **The Superintending Examiner (B Staff), The Patent Office, 25 Southampton Buildings, London, W.C.2. Telephone** HOLBORN 8721. **Ext.** 324.

McMASTER UNIVERSITY

HAMILTON, ONTARIO

Applications are invited for Assistant and Associate Professor of Electrical Engineering. Candidates should be well qualified academically, preferably to the doctorate level, and should have some research, design or teaching experience in control systems. The duties include teaching at undergraduate and graduate levels, organization and direction of laboratory classes, conducting research and supervising research students. Salary scales are open and competitive with those of industrial and research establishments. Additional stipends are offered to professors who remain on the campus for eleven months of the year and carry out research during this period.

Applications should be addressed to the Chairman, Department of Electrical Engineering, from whom further information may be obtained.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Immediate vacancy in Department of Chemical Engineering and Chemical Technology for graduate with good honours degree in chemistry, physics, or chemical engineering to do Ph.D. research on the explosibility of solid particle suspensions. Salary £500 to £600 per annum.

Applications to Dr. J. H. Burgoyne, Chemical Engineering Department, Imperial College, London, S.W.7.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

Applications are invited for the post of Lecturer/Assistant Lecturer in the Department of Physics. Salary in the scale £1,050 by £50 to £1,400 by £75 to £1,850 per annum (Lecturer), £800 by £50 to £950 per annum (Assistant Lecturer). Some preference may be given to applicants who have experience in the field of gas discharge or solid state physics.

Applications should reach the Registrar, The College, Keele, Staffs, from whom further particulars and application forms may be obtained, not later than February 28, 1961.

THE DURHAM COLLEGES in the University of Durham

Applications are invited for the post of Senior Research Assistant in Applied Physics, to join in a research programme on photoconductive and luminescent materials and devices. Candidates should preferably have had some postgraduate experience on these topics. The salary may be up to £950 a year according to qualifications and experience.

Applications (two copies), should be addressed to the Secretary, 38 North Bailey, Durham, before March 4, 1961. Testimonials should not be sent, but applicants should give the name of a person to whom reference may be made.

MONASH UNIVERSITY
CLAYTON, VICTORIA, AUSTRALIA
DEPARTMENT OF ANATOMY

Applications are invited for the following appointments: (a) Senior Lectureships and/or Lectureships; (b) Histologist as senior technical officer in charge of technical staff and facilities in the Department.

The Interim Council has recently appointed to the Chair of Anatomy Associate Professor G. C. Schofield of the University of Otago whose Department in 1961 will be involved in the planning of the permanent medical school and, principally, in preparing courses of instruction in Anatomy for 1962. Salary scales: Senior Lecturer, £A.2,480 by £A.100 to £A.2,950; Lecturer, £A.1,660 by £A.100 to £A.2,360; Histologist, not less than £A.1,790 per annum, with provision for superannuation on the F.S.S.U. basis. The initial salary in each case will be fixed having regard to a successful candidate's qualifications and experience. General conditions of appointment (including details of the provisions made for removal expenses, housing, etc.) may be had from the Registrar of the University, P.O. Box 92, Clayton, Victoria, Australia, or from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications, in duplicate, and giving the information listed in the general conditions of appointment, should be lodged with the Registrar of the University not later than March 31, 1961. An applicant resident elsewhere than in Australia or New Zealand should also send one copy of his application to the Secretary, A.U.B.C., 36 Gordon Square, London, W.C.1.

GEOPHYSICIST

A man with at least five to ten years' experience is required for work in Southern Africa. He must be a graduate of honours status or better, and conversant with all the usual geophysical techniques and field practice as applied to mineral prospecting. He will initially be based in Johannesburg but may be required to transfer elsewhere and to travel extensively. This is a senior post and its duties will involve the planning, organization and supervision of field work and interpretation of results. The appointment will be on a contract basis for a period to be mutually agreed and may be convertible to a permanency. Membership of pension and medical aid schemes compulsory. Fares both ways payable if three years service completed. Salary in accordance with qualifications and experience.

Applications should be sent to The Personnel Officer (Head Office), Anglo American Corporation of South Africa, Limited, Box 4587, Johannesburg, South Africa.

UNIVERSITY OF SOUTHAMPTON
DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

Applications are invited for Research Fellowships and Assistantships for the following research programmes: (a) Turbulence in Jets and its relation to noise. (b) The effect of noise on structures. (c) Cumulative fatigue damage of structures. Good honours degree or its equivalent in engineering, physics, mathematics or metallurgy essential, experience in vibration or noise analysis being an advantage. Fellowships are normally awarded only to persons with higher degrees and the salary will be in the region of £1,000 per annum. Salaries for Research Assistants are in accordance with qualifications and experience.

Applications (four copies), giving date of birth, details of qualifications and experience and the names of two referees, should be sent to the Secretary and Registrar, the University, Southampton, before March 18, 1961.

WAR OFFICE, RADWAY GREEN, Cheshire, require Metallurgist to take charge of section under Chief Metallurgist. Factory engaged in manufacture of small arms ammunition and an interesting range of components required in nuclear, aircraft and general engineering. New production techniques are being developed, explosive forming being a recent introduction. Work relates to manufacturing processes including casting, rolling, drawing and annealing copper alloy; extrusion of magnesium alloys, deep drawing and heat treatment of steel; special metal forming techniques and machining and surface protection of components. Qualifications and experience: honours degree in metallurgy or an Associateship of Institution of Metallurgists or equivalent. Experience in fields outlined under duties essential. Salary: £780 (age 25) to £1,220 per annum. Opportunities for establishment may arise.—Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting ref. F37/1A.

UNIVERSITY OF LONDON
KING'S COLLEGE

The College will require from Easter, 1961, if possible (failing that, on October 1), an Assistant Lecturer in Geology. Candidates should have a good Honours degree with special interests in mineralogy.

Salary scale: £800 by £50 per annum to £950, plus London allowance of £60, family allowances, and F.S.S.U. benefits.

Full conditions of appointment and application forms may be obtained from the Registrar, King's College London, Strand, W.C.2. Completed forms must reach him by February 28.

CENTRAL ELECTRICITY GENERATING BOARD

SENIOR SCIENTIFIC ASSISTANT (MALE)
(BACTERIOLOGY)

required at the Biological Laboratory, at present located at Grove Road, St. John's Wood, N.W.8, but which will be transferred to Leatherhead in mid-1961.

The work consists principally of sampling and culturing aquatic bacteria from marine and fresh waters. The successful candidate will be required to carry out laboratory work and to travel within England and Wales to assist in field work. Candidates should preferably hold the A.I.M.L.T., or equivalent, and possession of a driving licence will be an advantage.

Salary within the range £650 to £940 per annum, plus London Allowance whilst applicable.

Applications, stating age, qualifications, experience, present position and salary, to the Appointments Officer, 24/30 Holborn, London, E.C.1, by March 6. Envelopes should be marked "Confidential Ref. N/407A."

MIDLAND CENTRE FOR NEUROSURGERY
HOLLY LANE, SMETHWICK
RESEARCH BIOCHEMIST

Hospital devoted to treatment of diseases of the nervous system requires a medically qualified biochemist or graduate chemist with honours degree and experience in protein or enzyme chemistry to conduct research in collaboration with the Pathologist into effects of disease on muscle structure and metabolism. There is a well equipped laboratory available, and facilities including supervision for a higher degree, will be available at the University of Birmingham Department of Chemistry. Salary: £1,250 to £1,700 per annum. The appointment is for two years in the first place. The laboratory may be visited by arrangement with the Pathologist, Dr. A. L. Woolfe.

Applications, giving curriculum vitae and names of two referees, should be sent to the Group Secretary, West Bromwich and District Hospital Management Committee, Edward Street, West Bromwich.

WAR DEPARTMENT REQUIRES INDUSTRIAL Chemists for Royal Ordnance Factories in (a) Renfrewshire, Carmarthenshire, Somerset, to assist in administration and technical control of manufacture of acids, explosives, propellants, and associated development work. (b) Chorley, Lancs, responsible for operation of highly instrumented continuous process plant. Duties involve close control of variety of chemical engineering processes and a process laboratory. Qualifications: British of British parents; honours degree in chemistry or chemical engineering, A.R.I.C. or A.M.I.Chem.E. or equivalent. Salary: £575 (age 21) to £780 (age 25) to £1,220 according to age. Conditions: Paid sick leave, generous holidays. Five-day working week. 44 hours inclusive of meal breaks. Opportunities to compete for established posts. Good prospects of promotion to salary scale of £1,245 to £1,680.—Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting reference F56/1A.

MONASH UNIVERSITY
CLAYTON, VICTORIA, AUSTRALIA
SENIOR TEACHING FELLOWS IN CHEMISTRY

Applications are invited for appointment to the above-named posts. Appointees should have had some research experience and will be required to undertake research in one of the following fields: microwave spectroscopy and quadrupole coupling constants; theoretical chemistry (there will be access to two electronic computers); physical organic chemistry; reaction mechanism studies; synthesis, manipulation and physicochemical studies of volatile inorganic compounds; infra-red and ultraviolet spectroscopy; high resolution nuclear magnetic and electron spin resonance spectroscopy. Suitable work could lead to a Ph.D. degree. Duties will include a limited amount of class supervision and, in some cases, lecturing. The salary range is £A.1,400 to £A.1,600 per annum. Commencing salary will be fixed according to qualifications.

Further particulars are obtainable from the Registrar, Monash University, P.O. Box 92, Clayton, Victoria, Australia, or from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Inquiries of a technical nature should be addressed to Professor R. D. Brown, Monash University. Applications should be lodged with the Registrar of the University not later than March 31, 1961. Applicants resident outside Australia and New Zealand should also send a copy of their application to the Secretary, Association of Universities of the British Commonwealth.

UNIVERSITY OF BRITISH COLUMBIA
PHYSICS

Applications are invited for appointments to the teaching and research staff as well as for postgraduate fellowships and scholarships for the Session commencing in September, 1961. There are specific vacancies at the Assistant Professor level in Optical Spectroscopy, Meteorology and Low Energy Theoretical Nuclear Physics. Applications in other fields of physics will also be considered.

Further information and a copy of an illustrated brochure describing the activities and facilities of the Department may be obtained by writing to G. M. Shrum, Head, Department of Physics, University of British Columbia, Vancouver 8, B.C. Professor Shrum expects to be in London from March 16 to 25 and will be pleased to arrange personal interviews. Inquiries should be directed to B.C. House, 1 Lower Regent Street, London, S.W.1.

UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND

Applications are invited for appointment as Senior Lecturer in Mathematics at a salary of £1,750 per annum, rising by annual increments to a maximum of £2,000 per annum. Commencing salary will be in accordance with qualifications and experience. The appointee will be required to take charge of an IBM 1620 computer and to instruct courses in computer programming and in numerical mathematics. Previous experience of a computer would be an advantage, but the appointee will receive instruction on the 1620 machine. Approved fares to Christchurch will be allowed for the appointee, his wife and children. In addition actual removal expenses will be allowed within specified limits.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London, on March 10, 1961.

DEPARTMENT OF PHYSICS
UNIVERSITY OF WESTERN ONTARIO
LONDON, CANADA

Applications are invited for the positions of Assistant Professor and for Lecturer. Applicants should possess the Ph.D. degree or equivalent. Duties will involve undergraduate and graduate teaching and research. Salary, dependent on experience, $7,000 minimum and $5,500 minimum per annum.

GEOLOGISTS. FOUR POSITIONS AVAILable to teach in the fields of mineralogy, petrology petrography, paleontology, stratigraphy, structural geology, economic geology and geophysics. Good opportunities for research. Adequate salary. Two-year contract, renewable.—Inquiries, with complete credentials, to Escola de Geologia, Universidade da Bahia, Salvador, Bahia, Brazil. Courses in Portuguese, Spanish, English or French.

UNIVERSITY COLLEGE
IBADAN, NIGERIA

Applications are invited for (A) Senior Lectureship and (B) Lectureship in Department of Physiology. Salary scales (medically qualified candidates): (A) £2,275 by £100 to £2,775 per annum; (B) £1,200 by £100 to £1,700 (bar) £1,800 by £100 to £2,100 by £75 to £2,175 per annum. (Non-medically qualified candidates): (A) £2,275 by £75 to £2,575 per annum; (B) £1,200 by £75 to £1,650 (bar) £1,725 by £75 to £2,175 per annum. Passages paid for appointee, wife and up to five children under 11 years, on appointment, annual overseas leave and termination. F.S.S.U. Children's, car and outfit allowances. Part-furnished accommodation at rent not exceeding 7.7 per cent of salary.

Detailed applications (ten copies), naming three referees, by March 27, 1961, to Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF WESTERN AUSTRALIA
LECTURESHIP IN PHYSICS

Applications are invited for appointment to the above-named position. The construction of a new building to house the Department of Physics commenced recently, and it is anticipated that the building will be ready for occupation by the middle of 1962. The salary range for the position is £A1,750 by £A75 to £A2,350 per annum with superannuation similar to F.S.S.U. The appointee will be required to commence duties as early as possible.

It is important that intending applicants obtain details of the procedure to be followed in applying for the post and a copy of the Conditions of Appointment before submitting their applications. This information is available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on March 31, 1961.

WESTMINSTER HOSPITAL
DEPARTMENT OF CLINICAL MEASUREMENT
SENIOR TECHNICIAN

This Department deals with applied physics, chemistry and physiology in clinical practice and requires a Senior Technician. Applicants to be in I.M.L.T. Physics or Cardiological grades or to have similar scientific experience. Salary, according to qualifications and experience, in scale £710 to £870 per annum, plus London weighting.

Apply, naming two referees, to Secretary, Westminster Children's Hospital, Vincent Square, S.W.1.

INSTITUTE OF ANIMAL PHYSIOLOGY
BABRAHAM, CAMBRIDGE

Assistant Experimental Officer required to assist with investigations on sheep metabolism. Laboratory experience in Chemistry or Biochemistry essential. Minimum qualifications: G.C.E. in five subjects including two (science or mathematics) at "A" level, or equivalent. Salary according to age in scale £450 to £983 per annum. Contributory Superannuation Scheme.

Applications, with names of two referees, to the Secretary within fourteen days.

THE NATURE CONSERVANCY REQUIRE a Senior Scientific Officer for conservation work in East Anglia Region. Duties include acquiring an intimate knowledge of the flora and fauna, topography and land-use history of the area in connection with wild life conservation; planning and executing biological surveys; liaison with Government Departments, Local Authorities, Universities, Natural History Societies, farmers, landowners, etc., and co-operating with scientific and administrative staff in management of Nature Reserves and other sites. Post based on Norwich; considerable travelling involved. Candidates should have good honours degree in botany or zoology or other appropriate sciences, with postgraduate experience or equivalent qualification. Starting salary on scale £1,342 to £1,654, according to qualifications and experience. Superannuation F.S.S.U.

Applications, giving full particulars of age, education, experience, National Service, natural history interest and other relevant information, with names and addresses of two referees for ability and personality, to: The Nature Conservancy (E), 19 Belgrave Square, London, S.W.1, by February 28, 1961.

UNIVERSITY OF ST. ANDREWS

Applications are invited for the post of Lecturer in Physical and/or Inorganic Chemistry in St. Salvator's College, St. Andrews. Salary scale £1,050 to £1,850, with an efficiency bar at £1,400; starting salary according to qualifications and experience. F.S.S.U.; family allowance; grant towards expenses of furniture removal.

Six copies of applications, with the names of three referees, to be lodged by March 11, 1961, with the Joint Clerk to the University Court, College Gate, St. Andrews, from whom further particulars may be obtained.

UNIVERSITY OF ST. ANDREWS

Applications are invited for appointment as Assistant in Biochemistry in St. Salvator's College. Salary scale £800 by £50 to £950; starting salary according to qualifications and experience. F.S.S.U.; family allowance; grant towards expenses of furniture removal.

Five copies of applications, with the names of three referees, to be lodged by March 4, 1961, with the Joint Clerk to the University Court, College Gate, St. Andrews, from whom further particulars may be obtained.

THE DISTILLERS COMPANY LIMITED

RUBBER TECHNOLOGIST

The Company has a vacancy for a Rubber Technologist in the Central Research Department at Epsom, Surrey. The work includes long-term research and development in the field of rubber technology.

Candidates, aged not over 35, must have several years' experience of rubber technology or of laboratory work in the rubber industry. They should hold a degree in Chemistry, a qualification of the Institution of the Rubber Industry, or an equivalent qualification.

The Company operates a non-contributory pension scheme.

Write

STAFF MANAGER
THE DISTILLERS COMPANY LIMITED
21/22 BOLTON STREET
LONDON, W.1.

Quote Ref. 8/61.N.

NIGERIAN COLLEGE OF ARTS, SCIENCE AND TECHNOLOGY
ZARIA BRANCH

Applications are invited for the post of Lecturer in Zoology. Candidates should have a good honours degree, teaching experience up to degree level, and research experience. Appointment will be for two tours in the first instance. Contract salary scale £792 to £1,760. Entry point according to qualifications and experience. Gratuity of £25 to £37 10s. for each completed three months' residential service. Addition of £180 to £300 per annum for overseas appointees. Partly furnished quarters at one-twelfth basic salary rental. Free passages, including wife. Children's U.K. maintenance grant up to £150 per annum and passage assistance. Tours 10 to 18 months, but leave normally taken in long vacation.

Further information obtainable from the Council for Overseas Colleges, 12 Lincoln's Inn Fields, W.C.2, to whom applications (eight copies), giving age, qualifications, experience and the names of three referees, should be submitted before March 3, 1961.

LOUGHBOROUGH COLLEGE OF TECHNOLOGY
LEICESTERSHIRE

Applications are invited for the post of Assistant to the Director of Digital Computer Operation. Applicants should have some experience of digital computer work and preferably should hold graduate qualifications. Salary on a basic scale of £700 to £1,150 per annum, with additional allowances for graduates and training. The starting point on this salary scale will be fixed according to qualifications and previous experience.

Forms of application and further particulars may be obtained from the Academic Registrar. (In reply please quote ref. 2/AE).

UNIVERSITY OF COLLEGE OF GHANA

Applications are invited for (a) Lectureship or (b) Assistant Lectureship in Chemistry. Preference given to candidates who have specialized in Inorganic Chemistry. Salary scales (under review): (a) £G.1,000 by £G.50 to £G.1,350 by £G.75 to £G.1,800; £G.1,850 per annum (b) £G.900; £G.950 per annum. Entry point according to qualifications and experience. F.S.S.U. Outfit, family and other allowances. Passages for appointee and family on appointment, leave and normal termination. Part-furnished accommodation at a charge not exceeding 7.5 per cent of salary.

Detailed applications (six copies), naming three referees, by March 20, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

BRADFORD INSTITUTE OF TECHNOLOGY

Applications are invited for a Research Assistant in the Department of Mathematics. Candidates should have a good honours degree or Diploma in Technology or Mathematics. An interest in research in any of the fields of applied mathematics, numerical analysis, statistics and electronic computers would be an advantage. The Assistant will work under the direction of the Reader in Applied Mathematics. Salary in accordance with the Burnham Technical Award for Assistants Grade A (£520 to £1,000 per annum, plus training and graduate allowances).

Further particulars and forms of application may be obtained from the Registrar (Department F), Bradford Institute of Technology, Bradford 7.

HENRY PATTEN,
Clerk to the Governors.

UNIVERSITY COLLEGE OF WALES
ABERYSTWYTH
DEPARTMENT OF PHYSICS

Applications are invited for the post of Lecturer or Assistant Lecturer in Electronics in the Department of Physics.

Further particulars and forms of application can be obtained from the Registrar, to whom applications should be sent not later than March 18, 1961.

UNIVERSITY OF LONDON
READERSHIP IN INORGANIC CHEMISTRY AT QUEEN MARY COLLEGE

The Senate invite applications for the Readership in Inorganic Chemistry tenable at Queen Mary College (salary scale £1,675 to £1,975 to £2,425 a year, plus £80 London allowance).

Applications (ten copies) must be received not later than March 20, 1961, by the Academic Registrar, University of London, Senate House, W.C.1, from whom further particulars may be obtained.

SCIENCE GRADUATE, AGED PREFERably 25 to 35 years, to assist Head of Medical Research Department. Successful candidate will assemble data on specialized projects, prepare literature and deal with inquiries on relevant subjects. Organizing ability essential. Graduates with biological, biochemical or nutritional background considered.—Please write Personnel Manager, Vitamins Group, Upper Mall, London, W.6.

TECHNICIAN (FEMALE) REQUIRED FOR new, expanding Physics Laboratory. Work will be concerned chiefly with diagnosis and treatment using radioactive isotopes. Commencing salary up to £495 per annum depending on age and qualifications/experience. — Further particulars from Hospital Secretary, Dudley Road Hospital, Birmingham, 18.

LIBRARIAN. A LIBRARIAN IS REQUIRED for the Duncan Flockhart Research Laboratories which are engaged on a programme of medicinal research. A knowledge of the chemical literature is desirable and a graduate would be preferred.—Apply, stating age, qualifications and details of any previous experience, to Duncan, Flockhart and Co. Ltd., Wheatfield Road, Edinburgh 11, marking letter "Library."

UNIVERSITY COLLEGE LONDON (GOWER Street, W.C.1) requires Assistant Lecturer in Department of Psychology. Duties to commence October 1, 1961. Salary range £800 to £950, plus £60 London allowance, per annum. Superannuation and family allowance. Applicants should have special interest in experimental psychology.—Applications, to be received by March 18, 1961, should be sent to the Secretary, from whom further particulars may be obtained.

C.A.V.

Principal Research Officer

Mathematics

An experienced mathematician is required to undertake overall responsibility for mathematical and computational methods in a diesel and electrical engineering company.

This involves leadership of a section within the Research Department with established areas of research in combustion mathematics, fuel injection system hydraulics and the use of computers in electrical machine design. The section includes computer programmers.

A wide interest in solving problems of all kinds must be allied with a fundamental interest in combustion mathematics.

Replies, giving résumé of qualifications and experience, to Staff Employment Officer, C.A.V. Limited, Warple Way, London, W.3, quoting Ref. C.

UNIVERSITY OF MANCHESTER

Applications are invited for the following posts now vacant in the Department of Chemistry in the Faculty of Science: (a) Lecturer in Chemistry; candidates should have special interest in statistical thermodynamics and be willing to teach this subject to third year and postgraduate students. (b) Assistant Lecturer in Chemistry; candidates should have special interest in some branch of physical chemistry. (c) Senior Research Assistant; candidates should have experience in polymer science, and be willing to assist Professor Gee in the supervision of students carrying out research on the physical chemistry of polymers; the post is a temporary one, financed by a grant from D.S.I.R., but the forthcoming expansion of the department will offer good opportunities of permanent posts. Salary ranges: (a) and (c), £1,050 to £1,850 per annum, initial salary according to qualifications and experience; (b) £800 to £950 per annum. Duties to commence as soon as possible. Membership of F.S.S.U. and Children's Allowance Scheme.

Applications should be sent not later than March 7, 1961, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained.

UNIVERSITY OF LONDON

INSTITUTE OF LARYNGOLOGY AND OTOLOGY

330/332 Gray's Inn Road, W.C.1

There is a vacancy for a Senior Technician with experience in histological techniques in the Department of Pathology and Bacteriology of the Institute to assist with research projects, including histochemistry. Salary and grade according to qualifications and experience.

Applications, with two referees, to the Secretary-Administrator within seven days of the appearance of this advertisement.

MIDDLESEX COUNTY COUNCIL EDUCATION DEPARTMENT

Laboratory Assistants required at Brunel College of Technology, Woodlands Avenue, Acton, W.3, in: (a) Advanced Chemistry Laboratories. Interest in specialist fields such as lipids chemistry or gas chromatography advantage. O.N.C. standard in chemistry or previous experience in Technical College or industry essential. (b) Laboratories concerned with Chemistry and Technology of plastics materials. Experience in Technical College or industry particularly in plastics desirable. (c) Metallurgical Laboratories. Preference given to candidates with appropriate experience or National Certificate in metallurgy or equivalent. All posts: Salary: Miscellaneous III, £555 to £625 plus London weighting up to £40. Prescribed conditions.

Application forms from Principal, above address, returnable by March 3. (Quote F530N).

BRADFORD INSTITUTE OF TECHNOLOGY

DEPARTMENT OF BIOLOGICAL SCIENCES

Applications are invited for the post of Senior Lecturer in Microbiology. Candidates should be qualified to teach microbiology to final degree and Diploma in Technology standard. Salary scale, in accordance with the Burnham Technical Award namely, £1,550 to £1,750 per annum. The successful candidate will be encouraged to develop industrial contacts and to undertake research for which adequate facilities are available. Previous industrial and research experience, at a suitable level, will be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar (Department F), Bradford Institute of Technology, Bradford 7.

HENRY PATTEN,
Clerk to the Governors.

STATES OF GUERNSEY HORTICULTURAL ADVISORY SERVICE

VACANCY FOR EXPERIMENTAL OFFICER

A vacancy exists for an Officer who will be in charge of experiments on the Horticultural Experimental Station which is to be established in Guernsey. Applicants for this post should be under 30 years of age, interested in experimental work, preferably have a knowledge of statistics, and possess a degree in horticulture or a biological science or equivalent qualification. Final year students may apply. Opportunities for obtaining further experience will be provided for the successful candidate. The commencing salary will be according to age and qualifications.

Applications, giving details of qualifications, experience, relevant personal data, and naming three referees, should be forwarded to the President, States Board of Administration, States Office, P.O. Box No. 43, Guernsey, not later than March 7, 1961. Further particulars can be obtained from the same address.

NEW COLLEGE

OXFORD

OFFICIAL FELLOWSHIP IN MATHEMATICS

The College proposes to elect to an Official Fellowship in Mathematics, the duties of which will begin in October, 1961. The choice of the College will not necessarily be confined to those who apply.

Further particulars may be obtained from the Warden. Applications for the post must be received not later than March 11, 1961.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Experimental Officer in the Department of Chemistry in the Faculty of Science. Candidates should preferably have experience of quantitative work on the physical properties of polymers; minimum academic qualification is the Higher National Certificate; the person appointed would be required to assist in research work in polymer science, especially in connection with polymer characterization. The post is at present temporary, but it is hoped that a permanent appointment will be available later. Salary range: £700 to £1,000 per annum; initial salary according to qualifications and experience, and a lower starting salary could be offered if the selected candidate had no previous experience. Duties to commence as soon as possible.

Applications should be sent not later than March 7, 1961, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained.

SENIOR TECHNICIAN. APPLICATIONS are invited for this position in the Biochemistry Section of a newly-established research organization. Some experience in synthetic organic chemistry is essential. Excellent conditions, opportunity for collaboration in original research, contributory pension scheme. Salary commensurate with qualifications and experience.—Apply to the Secretary, Twyford Laboratories Ltd., Twyford Abbey Road, London, N.W.10.

HORTICULTURAL RESEARCH ASSISTANT required for practical development of new insecticides and fungicides on field scale, mainly on fruit. Degree in applied botany (plant pathology) or entomology essential, prefer bly with horticultural bias and postgraduate expe ence. Knowledge of fruit growing a distinct ad ntage. Salary according to age and experience.—Write, giving full details, to Personnel Officer, The Murphy Chemical Co. Ltd., Wheathampstead, St. Albans, Herts.

Senior Post for

PLANT PATHOLOGIST

available in

AN FORAS TALUNTAIS (The Agricultural Institute) for research work in its Plant Science and Crop Husbandry Division. Entry at level up to and including Principal Research Officer grade depending on qualifications and experience. Superannuation Scheme. ESSENTIAL: Honours degree in Agriculture, Horticulture or Science (including Botany). Experience in Virology an advantage.

Further particulars and application forms from Director, An Foras Talúntais, 33 Merrion Road, Dublin. Latest date for receipt of completed forms, March 16, 1961.

UNIVERSITY COLLEGE

CORK

PROFESSORSHIP OF DAIRY AND FOOD MICROBIOLOGY

The Governing Body invites applications for the vacant and pensionable Professorship of Dairy and Food Microbiology. Salary: £1,800 by £72 to £2,160 plus children's allowances. The pension scheme is non-contributory.

Particulars may be had from the undersigned. Applications will be received up to 12 noon on Saturday, April 15, 1961.

JAMES HURLEY,
Secretary.

INSTITUTE OF OPHTHALMOLOGY

(UNIVERSITY OF LONDON)

JUDD STREET, W.C.1

Vacancies exist for Laboratory Technicians in Research Department for work on Physiological Research of the Eye.

Further particulars from and applications, with names of two referees, to Secretary at above address.

A LADY OVER 25 IS REQUIRED TO RUN the Company's library, which forms part of the Technical Information Department and covers a wide range of electronic and engineering subjects. She will be responsible for accessioning classification by U.D.C. and cataloguing and should have reached A.L.A. standard in these subjects. Typing is an asset.—Please send details of education and experience to the Personnel Manager, the Plessey Company Limited, Vicarage Lane, Ilford, Essex.

FOR SALE AND WANTED

ALMOST ANY BACKNUMBERS AND volumes of *Nature* wanted. Also learned and scientific journals, transactions of most kinds. Further: *Notes and Queries*, the *Annual Register*, *Quarterly Review*, *Palmer's* and/or the *Official Index* to the *Times*, *British National Bibliography*, *English Catalogue of Books*, *Journal Royal Philosophical Society*, *Royal Statistical Society*, etc.—H. Pordes, 138 New Cavendish Street, London, W.1. MUSeum 5250.

LECTURES AND COURSES

UNIVERSITY OF LEEDS

ADVANCED COURSE IN ULTRA HIGH PRESSURE CHEMISTRY

(with applications to Geochemistry)

Applications are invited from graduates in chemistry, physics and mineralogy for admission to this two year course, starting in October, 1961, under the direction of Dr. R. S. Bradley. The D.S.I.R. has accepted this course as suitable for the tenure of its Advanced Course Studentships. Suitably qualified applicants will be given opportunities to work for higher degrees.

Applications and inquiries should be addressed to Dr. R. S. Bradley, Department of Inorganic and Structural Chemistry, The University, Leeds, 2.

IMPERIAL COLLEGE

LONDON, S.W.7

A course of postgraduate lectures on "Oxidation in Gas-Liquid Systems" arranged by Dr. C. F. Cullis will be given in the Department of Chemical Engineering during the week commencing Monday, March 20, 1961.

Details from the Registrar.

WOOLWICH POLYTECHNIC

MATHEMATICS DEPARTMENT

A course of six lectures on Simple Code Programming for the

STANTEC-ZEBRA COMPUTER

will be held on Thursdays from 7 to 9 p.m. commencing on March 2. This will include practical work on the computer installed in the Department and is intended for industrial users and other interested.

Applications to the Head of Mathematics Department. (Fee 10s.)

UNIVERSITY OF BIRMINGHAM

FACULTY OF COMMERCE AND SOCIAL SCIENCE

NOTICE TO GRADUATES AND THOSE ABOUT TO GRADUATE IN ARTS AND SCIENCE

The Faculty offers a one year course (leading to the Graduates' Commerce Diploma) for graduates wishing to prepare for a career in management.

Applications for admission to the course starting in October, 1961, and requests for further information, should be made as soon as possible to the Assistant Registrar (Commerce and Social Science), University of Birmingham, Birmingham, 15.

The Department of Scientific and Industrial Research has accepted this course as suitable, in the case of candidates with honours degrees in Science, for the tenure of its Advanced Course Studentships, and financial support will also be available for suitable graduates in Arts and Law.

UNIVERSITY OF LEEDS

ADVANCED COURSES IN X-RAY CRYSTALLOGRAPHY

Applications are invited from graduates in chemistry and physics for admission to this two-year course, starting in October, 1961. The D.S.I.R. has accepted the course as suitable for the tenure of its Advanced Course Studentships. Suitably qualified applicants will be given opportunities to work for higher degrees.

Applications and inquiries should be addressed to Dr. M. R. Truter, Department of Inorganic and Structural Chemistry, The University, Leeds, 2.

LANCHESTER COLLEGE OF TECHNOLOGY

COVENTRY

COURSE ON DEVELOPMENTS IN ORGANO-METALLIC CHEMISTRY

A short course will be held on Thursday and Friday, March 16 and 17, 1961. The lecturers will include Dr. J. Chatt (I.C.I. Ltd., Welwyn), Dr. W. Cooper (Dunlop Research Centre), Dr. G. G. Freeman (I.C.I. Ltd., Nobel Division), Dr. W. Gerrard (Northern Polytechnic) and Dr. E. S. Hedges (Tin Research Institute).

Course fee £1 2s. Further details and application forms from the Head of the Chemistry Department.

UNIVERSITY OF EDINBURGH

POSTGRADUATE COURSE IN BIOPHYSICS

Applications are invited from honours graduates in science and graduates in medicine, for the above one-year course which starts on October 1, 1961. Successful completion of the course leads to a Diploma in Biophysics. Lectures and practical classes will be given on biophysics and biophysical chemistry, on selected topics in animal and plant physiology and biochemistry, and on radiation physics and radiobiology. The course is intended to give as much as possible of the necessary background knowledge required for subsequent research in biophysics, radiation physics or radiobiology leading to a Ph.D. The D.S.I.R. has accepted this course as suitable for the tenure of its Advanced Course Studentships.

Applications for further information and for registration should be made to Dr. J. Dainty, Biophysics Department, University of Edinburgh, West Mains Road, Edinburgh, 9.

CHARLES H. STEWART,
Secretary to the University.

TRADE ANNOUNCEMENTS

SILICA CONES AND SOCKETS. VITREOsil silica tubing, polished silica discs and glazed sheet always in stock.—Custom built silica/quartz apparatus from Jencons, The Silica Centre, Mark Road, Hemel Hempstead, Hertfordshire. Boxmoor 4641.

BRIGHT'S REMOTE COLD CONTROLLED Microtome (cryostat) custom built for producing frozen sections for rapid diagnostic biopsies.—Full information on request to Bright's Refrigerator Service Ltd., 399 Portobello Road, London, W.10. LADbroke 4153.

GRANTS & SCHOLARSHIPS

NATO GRANTS

for participation in the CANADIAN THEORETICAL PHYSICS SEMINAR

Two grants of value $750 (£268) each are being offered by the North Atlantic Treaty Organization on a competitive basis to students of theoretical physics from NATO countries to attend the Second Quadrennial Theoretical Physics Seminar of the Canadian Association of Physicists to be held August 13 to September 9 at the University of Montreal. The seminar features lecture series by outstanding theoretical physicists as well as informal discussion on physics.

For further information and application forms write Dr. D. D. Betts, Department of Physics, University of Alberta, Edmonton, Canada. Deadline for applications is April 15.

ROYAL DUTCH SHELL

STUDENTSHIP IN GEOPHYSICS

Open to honours graduates in geology (with mathematics and/or physics at ancillary level), or physics, for two-year course in Geophysical Prospecting applied to the search for oil commencing October, 1961. Value £600 per annum out of which fees of £64 per annum and field work expenses must be paid.

Further particulars, and application forms which must be returned before May 15, 1961, obtainable from Registrar, Imperial College, London, S.W.7.

UNIVERSITY OF CAMBRIDGE

ESSO STUDENTSHIP IN CHEMICAL ENGINEERING

The Managers of the Esso Fund invite applications for an Esso Studentship. Applicants must be persons resident in Great Britain or Northern Ireland, and should hold or expect to hold a University degree with high honours in chemical engineering or in some other branch of engineering or in pure science. The Studentship will be tenable for two years from October 1, 1961. The Managers may renew a Studentship for a further tenure not exceeding one year. It will be the duty of the student to devote himself to full-time study and training for research in chemical engineering. The value of the Studentship will be £400 a year plus fees.

Application forms may be obtained from the Secretary, Department of Chemical Engineering, Pembroke Street, Cambridge, and should be completed and returned by May 1, 1961.

THE ROYAL SOCIETY

GOVERNMENT GRANT FOR SCIENTIFIC INVESTIGATIONS

Applications for grants from the first allotment of the Government Grant for Scientific Investigations for the year 1961, should be made as soon as possible on forms of application to be obtained from the Assistant Secretary of the Royal Society, Burlington House, London, W.1. No application can be considered which is received later than March 31, 1961.

Applicants must be of British nationality, resident in Great Britain or Northern Ireland. Grants may be made for purposes in connexion with the promotion and support of research in pure science other than for personal maintenance or payments of stipends; for the assistance of scientific expeditions and collections; but not in aid of scientific publications.

THE SYSTEMATICS ASSOCIATION

RESEARCH GRANT

A grant of £50 (fifty pounds) is available to encourage taxonomic research in Botany, Zoology or Palaeontology. Direct applications are invited from matriculated students of Universities in the United Kingdom. The grant is intended as an aid to graduates or undergraduates who have already decided on a project but are without sufficient funds to carry it out. It may be used for travelling and/or subsistence allowance in conjunction with other grants. Council favour a wide interpretation of the use which can be made of the grant as long as it is directed towards taxonomic research.

Applications, with the names of two referees, should be sent by May 31, 1961, to Mr. A. W. Exell, Chairman, Systematics Association, British Museum (Natural History), London, S.W.7.

UNIVERSITY OF WESTERN ONTARIO

LONDON, CANADA

DEPARTMENT OF CHEMISTRY

Demonstratorships, Research Assistantships, Scholarships, Fellowships, Bursaries, and Studentships, of value up to $2,800, are available for students working for the Ph.D. degree. Post-doctoral awards are available from $4,700. Excellent research facilities are on hand.

Inquiries, giving major field of interest, should be addressed to Professor F. L. M. Pattison, Head, Department of Chemistry, University of Western Ontario, London, Ontario, Canada.

"GURR'S" *is the Registered Trade Mark of* **GEORGE T. GURR LTD.**

Since 1915 "GURR'S" brand of MICROSCOPICAL STAINS and Reagents has become world-famous.

If you want this world-famous brand specify "GURR'S" and refuse any other.

Ask for catalogues

GEORGE T. GURR LTD.
136-138 NEW KINGS ROAD, LONDON, S.W.6

Secondhand Microscopes

We buy, sell or take in exchange

Clarkson's 338 High Holborn, W.C.1.

ESTABLISHED OVER A CENTURY

Opposite Gray's Inn Road. 'Phone: HOLborn 2149

INSTRUMENTS for HIRE

Scientific Circulations Ltd.

We have extensive stocks of Technical Journals, Periodicals and Textbooks. Special terms for Technical and Commercial Libraries. All Scientific and Technical publications purchased.

111, Eastbourne Mews, London, W.2

Telephone: AMBassador 6934

BACK ISSUES OF JOURNALS IN SCIENCE & THE HUMANITIES

ALWAYS REQUIRED BY

WM. DAWSON & SONS, LTD.,
BACK ISSUES DEPT.,
16 WEST STREET,
FARNHAM, SURREY, ENGLAND.

TEL: FARNHAM 4664 CABLES: DAWBOOKS, FARNHAM

Chemists rely on ISOMANTLES

Isomantle used at Laporte Titanium, Grimsby

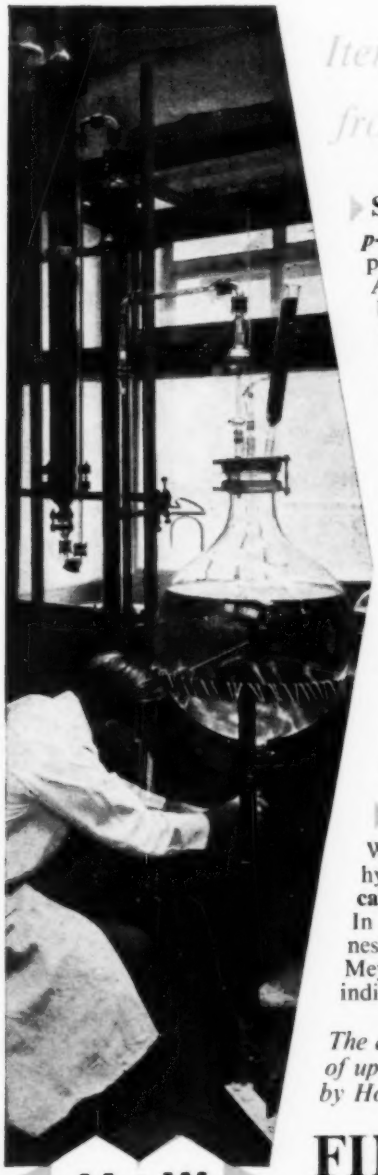
. . . . to answer all their heating problems safely and accurately. Do ask for latest catalogue.

ISOPAD ELECTRIC SURFACE HEATERS

ISOPAD LTD., BARNET BY-PASS, BOREHAM WOOD, HERTS.
Telephone : ELStree 2817/9, 3602

Incidental Information

No. 14



Items of interest from our laboratory notebooks

Simplified milk phosphatase test

***p*-Nitrophenylphosphoric acid, disodium salt** (*di*-sodium *p*-nitrophenyl phosphate) is used as a substrate in the **milk phosphatase** test of Aschaffenburg and Mullen now gaining in popularity and recognition because of its simplicity and speed. (See *J. Dairy Res.*, **16,** 58 (1949), and *Dairy Ind.*, **18,** 316 (1953)).

We make the reagent and can supply from stock. A suitable Lovibond Comparator for this test is obtainable from Baird & Tatlock (London) Ltd.

Karl Fischer catalyst

This well known method for the determination of **water** is widened in scope and increased in precision by the use of **Karl Fischer Catalyst** (*N*-ethylpiperidine)—available with instructions from Hopkin & Williams Ltd. Please write for instruction leaflet.

Uranium by spectrophotometry

Our **1-(2-pyridylazo)-2-naphthol** (**PAN** for short), already known as a metal indicator for complexometric titrations, (H. Flaschka and H. Abdine, *Mikrochim. Acta*, 770 (1956); *Anal. Abs.*, **4,** 794 (1957)) is now described as a spectrophotometric reagent of high specificity for **uranium** (H. Shibata, *Anal. Chim. Acta*, **22,** 479 (1960)).

Sensitive reagent for Calcium

We also make **di-(*o*-hydroxyphenylimino) ethane** (glyoxal-bis-(2-hydroxy anil)), a specific colour reagent for microgram quantities of **calcium** in solution.

In the solid state calcium oxide can be detected in mixtures of magnesium, strontium and barium oxides. (D. Goldstein and C. Stark-Meyers, *Anal. Chim. Acta*, **19,** 437 (1958)). Its use as a complexometric indicator is described by Goldstein in *Anal. Chim. Acta*, **21,** 339 (1959).

The above are further examples of the great range of up-to-date reagents made available by Hopkin & Williams Ltd.

H & W

FINE CHEMICALS

for research, analysis and industry

HOPKIN & WILLIAMS LTD., CHADWELL HEATH, ESSEX, ENGLAND

Branches: London, Manchester, Glasgow *Agents throughout U.K. and all over the world*

TAS/HW.13

Quicker than an analytical balance
more accurate than a simple balance

TORBAL COMES TO GREAT BRITAIN!

B.T.L. announce their appointment as sole U.K. agents for Torbal Balances, made by The Torsion Balance Co., Clifton, U.S.A. The torsion principle means quick, accurate weighing with direct reading, simply by adjusting a dial.

Torbal balances fill the gap between simple and analytical balances. Exceptionally robust, they may be used in laboratory or works and can be moved about like no other balance, without loss of accuracy. The complete range includes model DLT5, capacity 500g., accuracy 50 mg., price £61.10.0; and model DLT2, capacity 120g., accuracy 5 mg., price £67.10.0.

We are now demonstrating this remarkable American range of torsion balances all over the country. Write now for a demonstration on your bench.

BTL complete laboratory service

BAIRD & TATLOCK (LONDON) LTD., CHADWELL HEATH, ESSEX, ENGLAND

Branches in London, Manchester and Glasgow. *Agents throughout U.K. and all over the world*

TAS/BT 78

Printed in Great Britain by Fisher, Knight & Co., Ltd., The Gainsborough Press, St. Albans, and published by Macmillan & Co., Limited, at St. Martin's Street, London, W.C.2, and St. Martin's Press, Inc., 175 Fifth Avenue, New York 10, N.Y., U.S.A.—Saturday, February 18, 1961.